Agricultural Sciences Bachelor

1. Semester

First Year Examinations

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

Abstract

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

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

Objective

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

Content

1. Stoichiometry
   - Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
4. Basics of chemical thermodynamics
   - System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
   - Internal energy, Heat and Work, Enthalpy and reaction enthalpy.
6. Second law of thermodynamics
   - Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
9. Acids and bases
10. Dissolution and precipitation.
    - Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes

Online-Skript mit durchgerechneten Beispielen.

Literature


Weiterführende Literatur:


Taught competencies

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

<table>
<thead>
<tr>
<th>Communication</th>
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<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Personal Competencies

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

401-0251-00L

Mathematics I

Abstract

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

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

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

Content

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

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

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

Literature

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

Prerequisites / notice

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

Software

- MATLAB
- R
- SageMath
- Python

551-0001-00L General Biology I O 3 credits 3V U. Sauer, O. Y. Martin, A. Widmer

Abstract

Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

Objective

The understanding of some basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Content

The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogenetic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular & seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

Lecture notes

no script

Literature


Prerequisites / notice

The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.

701-0243-01L Biology III: Essentials of Ecology O 3 credits 2V C. Buser Moser

Abstract

This introductory lecture covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.

Objective

The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented.

A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.

Content

- Einfluss von Umweltfaktoren (Temperatur, Strahlung, Wasser, Nährstoffe etc.) auf Organismen; Anpassung an bestimmte Umweltbedingungen
  - Populationsdynamik: Ursachen, Beschreibung, Vorhersage und Regulation
  - Interaktionen zwischen Arten (Konkurrenz, Koexistenz, Prädation, Parasitismus, Nahrungsnetze)
  - Lebensgemeinschaften: Struktur, Stabilität, Sukzession
  - Ökosysteme: Kompartimente, Stoff- und Energieflüsse
  - Biodiversität: Variation, Ursachen, Gefährdung und Erhaltung
  - Aktuelle Naturschutzprobleme und -massnahmen
  - Evolutionäre Ökologie: Methodik, Spezialisierung, Koevolution

Lecture notes

Unterlagen, Vorlesungssfolien und relevante Literatur sind in Moodle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils spätestens am Freitagmorgen zur Verfügung.

Literature

  Bohle 1995. Limnische Systeme. Springer, ca. Fr. 50.-

701-0027-00L Environmental Systems I O 2 credits 2V C. Schär, N. Dubois, G. Velicer
The lecture provides a science-based exploration of environmental aspects from three research fields: earth, climate, and health sciences.

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

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

Slides are provided by instructors and are accessible via moodle.

Attending this course, the students will recognize the elements of the World Food System (WFS) approach and the problems it this

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

The course is part of the block exam after the first study year. Paper copies can be used (“Open Book”) during the on-line exam, but no other means are not allowed. The course is mainly taught in German, single might be in English.

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

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

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

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

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

Market failure: What happens when prices give wrong signals?

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

National accounts: How big is the Swiss economy?

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

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

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

Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Solved. Furthermore the students in the first year of studies shall be given some insight and outlook supporting the development of their views and interests in agricultural and food sciences further.

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

Fundamentals of Microscopy and Plant Biology


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

Numerals:

751-0013-00L World Food System

ECTS 3

Principles of Economics

Not for students belonging to D-MTEC!

ECTS 3
Laboratory Course: Elementary Chemical Techniques

A. de Mello, F. Jenny, M. H. Schroth

Objective
This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g. investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

Content
The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytical and synthetic tasks:

- Selected samples (e.g. soil and water) will be analysed with various methods, such as titrations, spectroscopy or ion chromatography. The chemistry of aqueous solutions (acid-base equilibria and solvation or precipitation processes) is studied.
- The synthesis of simple inorganic complexes or organic molecules is practised.
- The handling of chemicals and proper laboratory techniques represent the main learning targets. Furthermore, the description and recording of laboratory processes is an essential part of this course.

Lecture notes
The script will be published on the web.

Literature
A thorough study of all script materials is requested before the course starts.

Prerequisites / notice
Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Informatics

L. E. Fässler, M. Dahinden

Objective
The students learn to

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

Content

1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python

Lecture notes
All materials for the lecture are available at www.evim.ethz.ch.

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

Taught competencies

Subject-specific Competencies
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Method-specific Competencies

Social Competencies
Communication

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

Examination Block

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>402-0063-00L</td>
<td>Physics II</td>
<td>O</td>
<td>5</td>
<td>3V+1U</td>
<td>A. Vaterlaus</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the concepts and tools in Physics, with the help of demonstration experiments. The Chapters treated are Electromagnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena. Whenever possible, examples relevant to the students' main field of study are given.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.

Lecture notes
A script will be distributed.


Measuring object sizes with the microscope. Preparation of specimen for light microscopy. Plant tissue staining techniques.

Special features of plant cells: Plastids, vacuole, cell wall. Anatomy of seed plants: From cells to organs. Anatomy and function of various plant tissues (epidermis, vascular tissue, wood, etc.). Anatomy and function of different plant organs (root, stem, leaf, flower, fruit, seed).

Anatomical adaptations to different environments.
### Literature

<table>
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<tr>
<th>Code</th>
<th>Title</th>
<th>Authors</th>
<th>Publisher</th>
<th>Edition/Year</th>
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<tr>
<td>701-0071-00L</td>
<td>Mathematics III: Systems Analysis</td>
<td>O</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>C. Brunner, R. Knutti, S. Schemm, H. Wernli</td>
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<tr>
<td>401-0624-00L</td>
<td>Mathematics IV: Statistics</td>
<td>O</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>J. Ernest</td>
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<tr>
<td>752-4001-00L</td>
<td>Microbiology</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Ackermann, M. Schuppler, J. Vorholt-Zambelli</td>
</tr>
<tr>
<td>701-0501-00L</td>
<td>Pedosphere</td>
<td>O</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Kretzschmar</td>
</tr>
</tbody>
</table>

### 701-0071-00L Mathematics III: Systems Analysis

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

**Objective**
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

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

**Lecture notes**
Overhead slides will be made available through the course website.

**Literature**


### 401-0624-00L Mathematics IV: Statistics

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

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

**Content**

**Lecture notes**
Ausführliches Skript zur Vorlesung ist erhältlich.

**Literature**

**Prerequisites / notice**
Die Übungen (ca. die Hälfte der Kontaktstunden; einschließlich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung. Voraussetzungen: Mathematik I, II

### 752-4001-00L Microbiology

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

**Objective**
Teaching of basic knowledge in microbiology.

**Content**

**Lecture notes**
Wird von den jeweiligen Dozenten ausgegeben.

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

### 701-0501-00L Pedosphere

**Abstract**
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

**Objective**
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

**Content**
The course "Pedosphere" teaches and examines the competences process understanding and systems understanding.

**Lecture notes**
Polybook

**Literature**

**Prerequisites / notice**
Prerequisites: Basic knowledge in chemistry, biology and geology.
Die Vorlesung geht auf folgende Inhalte, mit spezifischen Anwendungen im Agrar- und Ernährungssektor ein:

- Molecular genetics (15%)
- Further reading:
  - R. Finger
  - Concepts and Theories
  - Slides and exercises will be provided in advance of each class via Moodle

Introduction to Nutritional Science

O 2 credits 1.5V M. B. Zimmermann, C. Wolfrum

*Only for Agricultural Sciences BSc.*

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

Objective

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

Content

-重要的概念来自人群、数量遗传学和分子遗传学，并解释它们在植物和动物种群应用中的重要性。
- 解释显性基因和等位基因变异的分子方法。
- 计算每单位时间预期遗传增益。
- 解释不同的概念从人口、分子和数量遗传学，并解释它们在农业科学中的重要性。

Lecturer notes

There is no script. PowerPoint presentations will be made available.

Literature

- Elmadfa I & Leitzmann C: Ernährung des Menschen
  - IUTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004
- Garrow JS and James WPT: Human Nutrition and Dietetics
  - Churchill Livingstone, Edinburgh, 2005

Agricultural Sciences Basic Courses

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

*Only for Agricultural Sciences BSc.*

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

Objective

After the course, the students will be able to:

- work with genetic polymorphisms and explain mechanisms underlying allele frequency changes in natural and experimental populations;
- determine factors affecting the selection intensity;
- explain the difference between genotypic and phenotypic values;
- quantify the expected genetic gain per time unit;
- explain important molecular methods to determine genetic polymorphisms;
- map traits in plant and animal populations using molecular marker information;
- integrate different concepts from population, molecular and quantitative genetics and explain their importance for applications in genetics in agricultural sciences.

Content

Molecular genetics (15%)

- DNA sequence variation
- Marker & genotyping technologies (SSRs, AFLPs, SNPs, KASP, GBS, RADseq, AmpSeq, Chip Technologies)

Population genetics (30%)

- Allele- and genotype frequencies in populations
- Hardy-Weinberg equilibrium
- Genetic drift, differentiation of populations
- Fitness, selection
- Inbreeding, relationship, effective population size

Quantitative genetics (40%)

- Quantification of expected genetic gain
- Quantification of expected genetic gain
- Genotypic value, allele substitution effect, breeding value

Integrative genetics (15%)

- Genome-wide association mapping
- Estimation of genomic breeding values

Lecturer notes

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

Literature

Further reading:

- Falconer & Mackay: Introduction to Quantitative Genetics
- Lütherstedt & Varshney: Diagnostics in Plant Breeding

Agricultural Sciences Disciplines

Agricultural Economics
<table>
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<tr>
<th>Number</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>351-1109-00L</td>
<td>Introduction to Microeconomics</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>M. Wörter, M. Beck</td>
</tr>
<tr>
<td></td>
<td>GESS (Science in Perspective): This course is only for students enrolled in a Bachelor's degree programme. Students enrolled in a Master's degree programme may attend &quot;Principles of Microeconomics&quot; (LE 363-0503-00L) instead. Note for D-MAVT students: If you have already successfully completed &quot;Principles of Microeconomics&quot; (LE 363-0503-00L), then you will not be permitted to attend it again.</td>
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<td>The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.</td>
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<td>Students acquire a deeper understanding of basic microeconomic models. They acquire the ability to apply these models in the interpretation of real world economic contexts.</td>
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<td>Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.</td>
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<td>Lecture notes</td>
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<td>Course material in e-learning environment <a href="https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php">https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php</a></td>
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<td>Prerequisites / notice</td>
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<td>This course &quot;Einführung in die Mikroökonomie&quot; (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 &quot;Principles of Microeconomics&quot; for Master students.</td>
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<td>Taught competencies</td>
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751-0903-00L Microeconomics of the Agriculture and Food Sector W+ 3 credits 2V S. Wimmer

| Content          | Der Agrar- und Lebensmittelsektor in der EU und der Schweiz - Preiselastizitäten von Angebot und Nachfrage im Ernährungssektor - Gewinnmaximierung - Grundlagen der Spieltheorie - Monopol / Monopolistischer Wettbewerb - Oligopol (Stackelberg, Cournot, Bertrand) - Monopson - Produktdifferenzierung - Preisdiskriminierung - Kartelle |      |      |       |                   |
| Prerequisites / notice Empfohlene Vorkenntnisse: - Grundkenntnisse der Ökonomie/Agrarökonomie - Vorlesung Einführung in die Mikroökonomie |      |      |       |                   |
| Taught competencies Subject-specific Competencies Concepts and Theories assessed |
|          Method-specific Competencies Decision-making assessed |
|          Social Competencies Negotiation assessed |
|          Personal Competencies Critical Thinking assessed |

751-0401-00L Optimization of Agricultural Production Systems W+ 3 credits 2G R. Huber

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

Objective

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

Content

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

Lecture notes

Handed out during lecture

Literature


Taught competencies

Subject-specific Competencies: Method-specific Competencies

Concepts and Theories: Analytical Competencies

Techniques and Technologies: assessed

Problem-solving: assessed

Critical Thinking: assessed

363-0537-00L Resource and Environmental Economics

W+ 3 credits 2G  L. Bretschger

Objective

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

Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failures; external effects, public goods, and environmental economics; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explore the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature


752-2120-00L Consumer Behaviour I

W 2 credits 2V  M. Siegrist, A. Bearth, A. Berthold

Objective

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

Literature


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

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

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 8 of 2345
Objective
At the end of the lecture, students know how mineral nutrients are taken up through roots and circulate in the plants and what their roles in plants are. They understand the importance of nutrients for yield formation and for crop product quality. They are able to propose fertilization plans adapted for field crops growing under Swiss conditions.

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

Lecture notes
The slides will be distributed

Literature
Schubert S 2006 Pflanzenernährung Grundwissen Bachelor Ulmer UTB
Richner W. & Sinaq S., 2017. Grundlagen für die Düngelung landwirtschaftlicher Kulturen in der Schweiz (GRUD 2017). Agrarforschung Schweiz 8 (6), Spezialpublikation,
http://www.tll.de/visuplant/vp_idx.htm

Taught competencies

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751-4108-00L Innovation in Smart Farming

W+ 3 credits 2G A. Walter

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

Content

751-4504-00L Plant Pathology I

W+ 2 credits 2G B. McDonald

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

Lecture Topics and Tentative Schedule

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

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

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

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

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

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


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

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

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


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

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes

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

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<tr>
<th>751-5003-00L</th>
<th>Sustainable Agroecosystems II</th>
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<th>K. Benabderrazik, J. Six</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation</td>
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<td>Objective</td>
<td>(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.</td>
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<td>(2) Learn and experiment on methods for field and laboratory investigations in agroecology.</td>
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<td>(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.</td>
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<td>(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.</td>
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<td>(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).</td>
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<td>Content</td>
<td>The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) in both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management). The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors’ roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholders in the food system in order to support a sustainable transformation.</td>
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<td>Prerequisites / notice</td>
<td>Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.</td>
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Abstract
The importance and specificities of the different horticultural crops are shown in this course in the autumn semester. It deals with fruit growing (8 h), berry production (4 h), vegetables (6 h) and viticulture (6 h).

Objective
Insight into and basic knowledge about production systems (yield formation and physiology, cultivation methods, main varieties, quality) of the horticultural crops important in Switzerland such as fruits, berries, vegetables and viticulture.

Content
The importance and specificities of the different horticultural crops are shown in this course in the autumn semester. It deals with fruit growing (8 h), berry production (4 h), vegetable growing (6 h) and viticulture (6 h). Under the responsibility of Agroscope representatives, basic knowledge of production systems (yield formation and physiology, cultivation methods, main varieties, quality) of these horticultural crops, which are important in Switzerland, is imparted.

Lecture notes
Delivered during the lectures by the different teachers, ELBA upload.

Literature
Not needed, maybe specific literature is specified by the different teachers.

Prerequisites / notice
Language and script: German or French, maybe selected parts in English.

Animal Sciences

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<td>Anatomy and Physiology of Man and Animals I</td>
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<td>S. E. Ulbrich, B. Abraham</td>
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Abstract
Imparts a basic understanding of physiology an anatomy in man and domestic animals, focusing on the interrelations between morphology and function of the organism, in particular of domestic animals. This is fostered by discussing all subjects from a functional point of view. The lecture consists of two consecutive parts.

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

Lecture notes
Handouts are provided by each lecturer separately.

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

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

Taught competencies

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Animal Housing and Behaviour

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Abstract
The overall goal of this course is to provide general knowledge about the behaviour, housing and welfare of domestic animals. Students will:
- Understand the basis of animal behaviour and how it is measured
- Acquire knowledge of housing systems and management of domestic animals
- Get a concept of animal needs and welfare
Contents

BEHAVIOR
- Fundamentals of animal behavior: mechanisms, development, function and evolution
- Overview of the natural behavioural repertoire of various livestock species and the resulting needs
- Insights in behavioural studies

ANIMAL HUSBANDRY
- Fundamentals of animal husbandry
- Insight in animal transportation and slaughter

BEHAVIOR vs. ANIMAL HUSBANDRY
- Adapt the husbandry practices to livestock-specific needs
- Recurrent problems in livestock management
- Concept of animal welfare

Performance Assessment: 1 written report (20%) + 1 final examination (80% of grade)

Handouts/Scripts are provided by the lecturers.

Specific literature recommendations will be provided by the lecturers as appropriate.

This lecture is part of the Agricultural Sciences Bachelor (3rd Semester).

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

Taught competencies

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<td>not assessed</td>
</tr>
<tr>
<td>not assessed</td>
<td>not assessed</td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td>not assessed</td>
<td>not assessed</td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Applied Animal Nutrition

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

Performance Assessment: 1 written report (20%) + 1 final examination (80% of grade)

Animal Feed and Feeding of Ruminants

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

Performance Assessment: 1 written report (20%) + 1 final examination (80% of grade)

Regulatory Physiology

Together with nervous control, hormones and cytokines play a role as signal mediators in particular situations. They can influence the metabolism in the organism and create a complex function in the organism.

- Thermoregulation (Fieber)
- Flüssigkeitshomöostase (Durchfall)
- Calciumregulation (Milchfieber)
- Energiehomöostase (Ketose)
- Schmerz (zootechnische Eingriffe)
- Stress (allostatische Last, Epigenetik)

Lecture notes
Unterlagen werden individuell von den Dozierenden abgegeben.

Literature
Spezifische Literatur wird individuell von den Dozierenden angegeben.

Prerequisites / notice
Diese Vorlesung ist Teil der BSc Agrarwissenschaften (5. Semester)

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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</tr>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<th>Method-specific Competencies</th>
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<tr>
<td></td>
<td>Decision-making</td>
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<th>Social Competencies</th>
<th>Communication</th>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tbody>
<tr>
<td></td>
<td>Creative Thinking</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
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Methods

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-0441-00L</td>
<td>Scientific Analysis and Presentation of Data</td>
<td>O</td>
<td>2</td>
<td>G</td>
<td>H. Pausch, N. K. Kadri, A. Leonard</td>
</tr>
</tbody>
</table>

Abstract
Students will get an introduction to the scientific work with data covering all steps from data import from Excel via statistical analyses to producing correct scientific graphical output. Exercises with the software R/RStudio will provide hands-on opportunities to get acquainted with data analysis and presentation in adequate graphs. Field data gathered with Prof. E. Frossard will be used.

Objective
This lecture with exercises gives an introduction to the scientific work with data, starting with data acquisition and ending with statistical analyses as they are often required for a bachelor thesis (descriptive statistics, linear regression, simple analyses of variance etc.). Using open-source R/RStudio software will be the primary focus via a hands-on approach. An important aspect will be to learn which graphical representation of data are best suited for the task (how can data be presented clearly and still scientifically correct?)

Content
Tentative Programme:
- Introduction
- Introduction to 'R'
- Data import and graphical presentation
- Preparation of own data from field course with Prof. E. Frossard / from 4th semester
- Correct and problematic graphical data displays
- Statistical distribution and confidence intervals
- Statistical tests - Repetition and hands-on applications
- Correlation analysis
- Linear regressions
- Analysis of Variance
- Discussion of ANOVA results with Prof. E. Frossard

Last week of semester: examination (Leistungskontrolle)

Lecture notes
Mainly German (with some English passages from text books)

Prerequisites / notice
Theoretical background in ensemble statistics from the mandatory course in the 4th semester; students should have cleared the examination of that fundamental course to be able to follow

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
Die Studierenden kennen die Grundlagen und die Konventionen des wissenschaftlichen Schreibens in den Naturwissenschaften, können wissenschaftliche Literatur suchen und verwalten sowie wissenschaftliche Publikationen analysieren. Sie setzen das Gelernte beim Schreiben eines eigenen Textes um.

Objective
Die Studierenden kennen die Grundlagen und die Konventionen des wissenschaftlichen Schreibens in den Naturwissenschaften. Sie setzen das Gelernte beim Schreiben eines kritischen Literaturberichtes zu einem agrarwissenschaftlichen Thema ihrer Wahl um. Die Lehrveranstaltung bereitet die Studierenden auf weitere schriftliche Arbeiten im Studium der Agrarwissenschaften vor, beispielsweise auf die Bachelor-Arbeit.

Lecture notes
Es wird ein Skript abgegeben.

Prerequisites / notice
Negotiation

Students will be able to:

a) solve linear and non-linear optimization problems in the context of agricultural production;

b) properly interpret concepts and theories of optimization.

Abstract

Die Lehrveranstaltung ist zweiteilig aus einem Laborpraktikum und einem angewandten Methodentraining aufgebaut. Im Laborpraktikum werden an 6 Kurstagen die wichtigsten Techniken der Molekularbiologie gelehrt. Das folgende Methodentraining findet an 5 Kurstagen im Block in einer der beteiligten Forschungsgruppen statt, um die wichtigsten Methoden aus dem jeweiligen Fachgebiet praxisnah anzuwenden.

Objective

- Aneignung on verhaltenswissenschaftlicher Theorien
- Vertiefung des Verständnisses von molekularen, physiologischen und biochemischen Prozessen in aktuellen agrarwissenschaftlichen Themenbereichen
- Aneignung von Kompetenzen für zukünftige Bachelor-, Master-, und Doktorarbeiten
- Kritische Beurteilung der angewandten Methoden für verantwortungsvolle Forschung

Content

Molekularbiologisches Laborpraktikum: DNA Extraktion, DNA Quantifizierung, PCR, Molekulare Marker, Gelelektrophorese, DNA Sequenzierung, Bioinformatik, qPCR

Angewandtes Methodentraining: Inhalte definiert durch die jeweiligen Arbeitsgruppen

Lecture notes

Laborjournal

Wird einsprechend den Kursinhalt abgegeben.

Literature

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Social Competencies

Cooperation and Teamwork

Personal Competencies

Critical Thinking

Taught

assessed

assessed

assessed

assessed

Electives

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

Number

Title

Type

ECTS

Hours

Lecturers

751-0903-00L

Microeconomics of the Agriculture and Food Sector

W

3

2V

S. Wimmer

Abstract

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

Objective


Content

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

Literature


Prerequisites / notice

Empfohlene Vorkenntnisse:

- Grundkenntnisse der Ökonomie/Agrarökonomie
- Vorlesung Einführung in die Mikroökonomie

Taught

assessed

assessed

assessed

assessed

751-0401-00L

Optimization of Agricultural Production Systems

W

3

2G

R. Huber

Abstract

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

Objective

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

Content

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

Lecture notes

Handed out during lecture

Literature


Method-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

assessed

assessed

assessed

363-0537-00L

Resource and Environmental Economics

W

3

2G

L. Bretschger

Abstract

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

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

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

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

Lecture Topics and Tentative Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.</td>
</tr>
<tr>
<td>2</td>
<td>Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.</td>
</tr>
<tr>
<td>3</td>
<td>Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.</td>
</tr>
<tr>
<td>4</td>
<td>Fungal and oomycete life cycles, disease cycles, infection processes, colonization, pythotoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.</td>
</tr>
<tr>
<td>5</td>
<td>Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).</td>
</tr>
<tr>
<td>6</td>
<td>Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.</td>
</tr>
<tr>
<td>8</td>
<td>Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.</td>
</tr>
<tr>
<td>9</td>
<td>Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.</td>
</tr>
<tr>
<td>10</td>
<td>Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.</td>
</tr>
<tr>
<td>13</td>
<td>Cultural control methods: fertilizers, crop rotations.</td>
</tr>
<tr>
<td>14</td>
<td>Open lecture.</td>
</tr>
</tbody>
</table>

Lecture notes

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

### Literature


### Prerequisites / notice

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

Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Cooperation and Teamwork assessed
Sensitivity to Diversity assessed
Personal Competencies
Critical Thinking assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

751-7101-00L Applied Animal Nutrition W 2 credits 2G S. Müller, G. Bee, M. A. Boessinger, F. Leiber, F. Sutter

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

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

Content
- Programmteil Wiederkäuer: Einführung in die Winterfütterungsplanung für Milchkühe, Betriebsbesuch (Erfassung aller notwendigen Daten inkl. Futterprobenentnahme für eine konkrete Planung auf einem Praxisbetrieb), Besonderheiten der Milchviehfütterung (Laktationsverlauf, Jahreszeit, etc.); Einführung in den LBL-Fütterungsplan, Möglichkeiten der Futterbeurteilung und - bewertung mit praktischer Beurteilung der gesammelten Proben, Berechnungen und Besprechung Fütterungsplan, Aufstellung der Mineralstoffbilanz, Vorführung von PC-Software zur Fütterungsplanung Vorstellen und diskutieren des Fütterungsplanes auf dem Praxisbetrieb durch die Gruppe.

- Programmteil Nicht-Wiederkäuer: Der Energie- und spezifische Nährstoffbedarf beim Schwein und Geflügel; Besonderheiten der Fütterung in den verschiedenen Produktionsphasen; Fütterungsempfehlungen und hinweise. Rationengestaltung und Rezeptoptimierung für Mischfuttermittel anhand verschiedener Beispiele; Einsatzgrenzen von Futtermittel; technologische Futterbearbeitung.

Lecture notes
Handouts in German language will be provided by each lecturer when starting his part of the lecture.

Literature
Die Dozierenden geben in der Lehrveranstaltung die relevante Literatur bekannt.

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

751-7103-00L Animal Feed and Feeding of Ruminants W 2 credits 2V M. A. Boessinger

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

Objective
Purchase of basic skills in agricultural livestock nutrition.

Content

Lecture notes
Script is available in German language and will be provided by each lecturer when starting his part the lecture.

Literature
Eine Literaturliste ist im Skript enthalten.

Prerequisites / notice
Fach mit benoteter Semesterendprüfung

751-6121-00L Regulatory Physiology W 2 credits 2V S. E. Ulbrich, M. Saenz de Juano Ribes

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

Objective

Content
- Thermoregulation (Fieber)
- Flüssigkeits- und Elektrolytregulation (Durchfall)
- Calciumregulation (Milchfieber)
- Energiehomöostase (Ketose)
- Schmerz (zooethischen Eingriffe)
- Stress (allostatische Last, Epigenetik)

Lecture notes
Unterlagen werden individuell von den Dozierenden abgegeben.

Literature
Spezifische Literatur wird individuell von den Dozierenden angegeben.

Prerequisites / notice
Diese Vorlesung ist Teil der BSc Agrarwissenschaften (5. Semester)
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

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

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

Objective
Students know the thirteen principles of the High Level Panel of Experts (HLPE) of the Committee on World Food Security as well as the ten elements of agroecology as suggested by FAO and can critically reflect on the important properties as well as benefits and trade-offs of agroecological systems and approaches.

Students will be able to transfer their disciplinary and interdisciplinary knowledge about the thirteen principles as guiding principles for policymakers, practitioners and other stakeholders across the food system in planning, managing and evaluating agroecological transitions. Students engage in a lively and critical debate and learn about scientific contributions to agroecology. Based on the knowledge gained, students are able to form a personal opinion on the role of agroecology as well as to reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

Content
The course is designed as a combination of a series of five public lectures/webinars on “Agroecology in the transition to sustainable food systems” delivered by national and international scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a debate format. The public lectures bring different perspectives to the discussion and are intended to fuel the students debates in the second part of each course. Each of these debates revisits one of the thirteen principles of agroecology. Each debate which is organised in form of a role play will involve different groups of students taking on roles of various food system actors. All groups will synthesize their discussions in a short report.

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

Literature
Report of HLPE on agroecology:

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

Bachelor’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-1020-10L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>14</td>
<td>30D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Agricultural Sciences Bachelor - Key for Type

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

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium |    |                          |

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
### Educational Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
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<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
<tr>
<td></td>
<td>This lecture is only apt for students who intend to enrol in the programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about learning in childhood and adolescence.</td>
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</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This course looks into scientific theories and also empirical studies on human learning and relates them to the school.</td>
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<td><strong>Objective</strong></td>
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<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
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<td><strong>Content</strong></td>
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<td>Thematische Schwerpunkte:</td>
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<td>Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissensstransfers; Lernen durch Instruktion und Erklärungen: Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<td><strong>Lecturers</strong></td>
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<td></td>
<td>E. Stern</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>This lecture is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
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<tbody>
<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<td><strong>Objective</strong></td>
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<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td>- Get information about recent literature on learning and instruction</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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<tr>
<td>851-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td>- Getting to know intelligence tests</td>
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<tr>
<td></td>
<td>- Understanding findings relevant for education</td>
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<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>C. M. Thurn, T. Braas, P. Edelsbrunner</td>
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<td><strong>Abstract</strong></td>
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<td>Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.</td>
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<td><strong>Objective</strong></td>
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<td>- Understand research methods used in the empirical educational sciences</td>
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<td>- Understand and critically examine information from scientific journals and media</td>
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<td>- Understand pedagogically relevant findings from the empirical educational sciences</td>
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<tr>
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<tr>
<td>851-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>U. Markwalder, S. Maurer, S. Peteranderl-Rüschoff</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>The successful participation in EW1 (&quot;Human Learning&quot;) and EW2 (&quot;Designing Learning Environments for School&quot;) is recommended, but not a mandatory prerequisite.</td>
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In this class, students will learn concepts and skills for coping with psychosocial demands of teaching

Objective

Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.

- They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
- They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

851-0242-11L Gender Issues In Education and STEM
Number of participants limited to 30.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

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

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

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

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

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

851-0228-00L Formation of Knowledge in STEM Fields in Primary and Secondary School
Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enroled after successful participation in the course 851-0240-00L "Human Learning (EW 1)".

Abstract
The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

Objective
- Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

Content
Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

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

Number Title Type ECTS Hours Lecturers
751-9020-00L Teaching Internship Including Examination Lessons in Agricultural Science W 6 credits 13P G. Kaufmann

Abstract
The teaching internship can just be visited if all other courses of TC are completed. Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

Objective
- Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Die Themen für die beiden Prüfungslektionen am Schluss des Praktikums erfahren die Studierenden in der Regel eine Woche vor dem Prüfungstermin. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie bis am Vortag um 12 Uhr den beiden Prüfungsexpernten (Fachdidaktiker/-in, Departementsvertreter/-in) ein. Die gehaltenen Lektionen werden kritierrumbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltenen Lektionen im Rahmen eines kurzen Kolloquiums.
Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

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

Content
Themenatische Schwerpunkte:

Lernformen:

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

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

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Agricultural Sciences TC - Key for Type
| O  | Compulsory | E-  | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z   | Courses outside the curriculum |
| W  | Eligible for credits | Dr  | Suitable for doctorate |

Key for Hours
| V  | lecture | P   | practical/laboratory course |
| G  | lecture with exercise | A   | independent project |
| U  | exercise | D   | diploma thesis |
| S  | seminar | R   | revision course / private study |
| K  | colloquium |

ECTS
- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
The Forum "Livestock in the World Food System" is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from different fields such as animal science, economics, and environmental sciences. The course provides the scientific basis of the central aspects of reproduction and nutrition physiology of ruminants, and of the implications for animal health, product quality, and breeding programs. Means of knowledge transfer include interdisciplinary approaches, disciplinary parts, web-based learning, and self-study.

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

In summary, the course covers:
- Introduction: 2 h
- Ruminant Anatomy: 2 h
- Hohenheim Gas Test: 8 h
- Calf health: 8 h
- Reproduction Techniques: 8 h
- Fertility in Cows: 12 h
- Disciplinary topics: 32 h
- Ruminant Nutrition Physiology: 12 h
- Reproduction in Ruminants: 8 h
- Lectures held by the students: 4 h

In summary:
- Contact hours: 58 h
- Self-study within semester: 30 h
- Self-study in semester break: 32 h

Total: 120 h

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

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

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

Feedback on the presentation style of a student

Number of participants limited to 25

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

Upload your application on Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=17604
Deadline for the application is 16th September 2022. Selection made until 16th September. Questions regarding the application to johanna.jacobi@usys.ethz.ch.

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

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

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

Literature
Literatuerlist provided on Moodle.

▶▶▶ Livestock Biology

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<tbody>
<tr>
<td>751-7211-00L</td>
<td>Ruminal Digestion</td>
<td>W+</td>
<td>1</td>
<td>1G</td>
<td>not available</td>
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<td>Does not take place this semester.</td>
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Abstract
This course broadens the knowledge in one of the most important aspects of ruminant nutrition: the microbial digestion in the rumen (and in the hindgut). For a comprehensive understanding of the rumen microbial ecosystem, the mechanisms of nutrient fermentation and the synthesis of microbial protein, thorough basics are provided. Apart from lectures, group and laboratory exercises are included.

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

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

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

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

2 h Final seminar

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

Lecture notes
Lecture notes are provided via Moodle.

Literature
Will be communicated at the start of the course.

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

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

751-6113-00L Endocrinology and Biology of Reproduction W+ 3 credits 2G S. E. Ulbrich, S. M. Bernal Ulloa
Abstract
Endokrinologie und Reproduktionsbiologie der Säugetiere und des Menschen (Anatomie, Morphologie, Physiologie, Regelmechanismen) Die Systematik der Reproduktionshormone und der Hormonrezeptoren wird erläutert, die Wirkungsmechanismen (Bildung; orale Bioverfügbarkeit; Elimination) erklärt. Mit diesen Grundlagen wird das Verständnis der Regulation der Fortpflanzung umfassend erörtert.

Objective
Die Studierenden erlangen das grundlegende theoretische Verständnis und Fachwissen zur Endokrinologie der Reproduktion und zur weiblichen und männlichen Reproduktionsbiologie. Sie können darüber hinaus pathologische Situationen (Fortpflanzungsstörungen) und deren vielfältige Ursachen in den physiologischen Kontext einordnen.

751-7310-00L Bioactive Food and Feed Components

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

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

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

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

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

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

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

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

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

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

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

Literature
Papers will be assigned and downloaded from a web page announced during the lecture.

>>>> Livestock Genetics

Number
Title
Type
ECTS
Hours
Lecturers

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

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

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

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

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

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

751-6305-00L Livestock Breeding and Genomics

Abstract
Swiss routine breeding value estimation/genetic evaluation systems of cattle, pig, sheep and goats are presented with methods and evaluated traits. Examples will be demonstrated using the statistical software R.

Objective
The students know the theoretical and practical application of breeding value estimation in Switzerland for cattle, pig, sheep and goats. The students are able to interpret estimated breeding values.

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

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

Literature
To be announced in the lectures.

>>>> Methodology Competences

>>>> Methods for Scientific Research
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<tbody>
<tr>
<td>751-3801-00L</td>
<td>Experimental Design and Applied Statistics in Agroecosystem Science</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Hund, C. Grieder, R. Kölliker</td>
</tr>
</tbody>
</table>

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

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

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

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

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

**Lecture notes**
Handouts will be available (in English).

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

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

**Taught competencies**
- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
  - Media and Digital Technologies assessed
  - Problem-solving assessed

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

**Number**
W+ 3 credits 6P not available

**Abstract**
Die "Funktionelle Histologie" beschreibt die histologischen und zytologischen Strukturen mit ihren jeweiligen Aufgaben und Wechselwirkungen innerhalb ausgewählter Organ-Systeme. Die endokrinologisch relevanten Organe und deren Präparation werden am Beispiel des Rindes kongenialiert.

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

**Content**
Jeder/r Studierenden wird ein Organ zugeteilt, mit welchem sie/r sich intensiv theoretisch und praktisch auseinandersetzt. Anhand dieses Organs als rotem Faden, welches vom Schlachthof bereitgestellt, eingebettet, geschnitten, gefärbt und mikroskopiert wird, werden die Lernziele erreicht.


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

In der Nachbereitung zum Praktikum wird ein Bericht angefertigt, in dem die Vorgehensweise (Verfahrensprotokoll), die Befunde (Ergebnisprotokoll) und die kritische Auseinandersetzung mit den Inhalten des Praktikums (kritische Beurteilung) dokumentiert werden.

**751-6129-00L**
Practical Course Epigenetics

**Number**
W+ 3 credits 6P not available

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

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

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

1SECTS

Type

6P

None

Hours

None

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

Abstract

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

Objective

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

Content

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

Lecture notes

None

Specific readings after enlisting in a particular research group.

Prerequisites / notice

The number of training slots in the various groups is limited. It is therefore highly recommended to contact the group leaders early enough (first come first serve).

The full integration in a research group often means to work on weekends.

The total time budget is equivalent to about 180 hours. Active participation in group meetings (discussion, presentation) and short written reports about the work conducted are required for the 6 credit points. There are no grades, it is only pass or fail.

751-6003-01L

Training Course in Research Groups (Small) » W+ 3 credits 6P

S. M. Bernal Ulloa, S. Neuenschwander, H. Pausch, M. Saenz de Juano Ribes, S. E. Ulbrich

Abstract

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

Objective

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

Content

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

Lecture notes

None

Specific readings after enlisting in a particular research group.

Prerequisites / notice

The number of training slots in the various groups is limited. It is therefore highly recommended to contact the group leaders early enough (first come first serve).

The full integration in a research group often means to work on weekends.

The total time budget is equivalent to about 90 hours. Active participation in group meetings (discussion, presentation) and short written reports about the work conducted are required for the 3 credit points. There are no grades, it is only pass or fail.

Project Management for Scientific Research

<table>
<thead>
<tr>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>751-6001-00L</td>
<td>Forum: Livestock in the World Food System</td>
<td>W+</td>
<td>2</td>
<td>1S</td>
<td>S. Meese</td>
</tr>
</tbody>
</table>

Abstract

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

Objective

In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society).

The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion.

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

Content

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

Part 1

Aspect 1 - Oral presentation: The students form small groups and are lecturers.
Aspect 2 - Chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.

Aspect 3 - Feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

Part 2

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

Lecture notes

no scriptum

Prerequisites / notice

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

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Adaptability and Flexibility
Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions.

This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, Resilience to Soil physics.

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

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

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

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

Taught competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making not assessed
- Problem-solving assessed
- Project Management assessed

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

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

Major in Plant Sciences
Disciplinary Competences
Agronomy and Plant Breeding

Agronomy and Plant Breeding

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>751-4104-00L</td>
<td>Alternative Crops</td>
<td>W+</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Walter, K. Berger Büter</td>
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<tr>
<td>751-3603-00L</td>
<td>Current Challenges in Plant Breeding</td>
<td>W+</td>
<td>2 credits</td>
<td>2G</td>
<td>B. Studer, A. Hund, R. Kölliker</td>
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<tr>
<td>751-4704-00L</td>
<td>Weed Science</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>B. Streit, U. J. Haas</td>
</tr>
</tbody>
</table>

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

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

Abstract
The seminar 'Current challenges in plant breeding' aims to bring together national and international experts in plant breeding to discuss current activities, latest achievements and future prospective of a selected topic/area in plant breeding.

Objective
The educational objectives cover thematic, methodic as well as social and personal competencies:
- Deepening of scientific knowledge in plant breeding
- Critical evaluation of current challenges and new concepts in plant breeding
- Promotion of collaboration and Master thesis projects with practical plant breeders
- Social/personal competencies:
  - Independent literature research to get familiar with the selected topic
  - Critical evaluation and consolidation of the acquired knowledge in an interdisciplinary team
  - Establishment of a scientific presentation in an interdisciplinary team
  - Participation in the BSc course 'Pflanzenzüchtung' is strongly recommended, a completed course in 'Molecular Plant Breeding' is advantageous.

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

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Crop Health

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

<table>
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<tr>
<th>Number/Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-5101-00L Biogeochemistry and Sustainable Management</td>
<td>W+</td>
<td>2</td>
<td>2G</td>
<td>N. Buchmann, I. Feigenwinter, V. Klaus</td>
</tr>
</tbody>
</table>

Objective

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

Content

Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.
Content
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

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

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

Lecture notes
Handouts will be available in moodle.

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

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Method-specific Competencies
- Critical Thinking: assessed
- Self-direction and Self-management: not assessed

Personal Competencies

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

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

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

Lecture notes
Documents will be distributed during the lecture.

Literature
Documents will be distributed during the lecture.

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

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

Number of participants limited to 20.

Priority will be given to students in Agricultural Sciences.

Priority will be given to students in Agricultural Sciences.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

Social Competencies

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

751-5125-00L
Stable Isotope Ecology of Terrestrial Ecosystems
R. A. Werner, N. Buchmann, A. Gessler, M. Lehmann

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

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

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

### Methodology Competences

#### Seminar in Plant Sciences

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<th>Number</th>
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<tr>
<td>751-5115-00L</td>
<td>Current Aspects of Nutrient Cycle in Agro-Ecosystems</td>
<td>W+</td>
<td>2 credits</td>
<td>1S</td>
<td>E. Frossard, A. Oberson Dräyer</td>
</tr>
</tbody>
</table>

**Abstract**
The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is “Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments”.

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

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

#### Taught competencies

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

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

**Social Competencies**
- Communication
- Cooperation and Teamwork

**Personal Competencies**
- Creative Thinking
- Self-direction and Self-management

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<tr>
<td>751-4003-01L</td>
<td>Current Topics in Grassland Sciences (HS)</td>
<td>W+</td>
<td>2 credits</td>
<td>2S</td>
<td>N. Buchmann</td>
</tr>
</tbody>
</table>

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

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

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

**Lecture notes**
None

**Prerequisites / notice**
Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.
751-2105-00L  
**Political Ecology of Food and Agriculture**  
Number of participants limited to 25

A motivational application is required:

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

Upload your application on Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=17604  
Deadline for the application is 10th September 2022. Selection made until 16th September. Questions regarding the application to johanna.jacobi@usys.ethz.ch.

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

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

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

### Literature
Literaturelist provided on Moodle.

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

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<td></td>
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### Design, Analysis and Communication of Science

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<th>Number</th>
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<tr>
<td>751-3801-00L</td>
<td>Experimental Design and Applied Statistics in Agroecosystem Science</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>A. Hund, C. Grieder, R. Kölliker</td>
</tr>
</tbody>
</table>

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

### Objective
Students will know various statistical analyses and their application to science problems in their study area as well as a wide range of experimental design options used in environmental and agricultural sciences. They will practice to use statistical software packages (R), understand pros and cons of various designs and statistics, and be able to statistically evaluate their own results as well as those of published studies.
This course does not provide the mathematical background that students are expected to bring along when signing up to this course. Alternatively, students can consider some aspects of this course as a first exposure to solutions in experimental design and applied statistics and then deepen their understanding in follow-up statistical courses.

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

Abstract
This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, Resilience to Soil physics.

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

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

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

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

Taught competencies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Problem-solving</td>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 32 of 2345
Objective

After taking the class, students will be able to

1) Define what marketing is and describe its role at different stages of the value chain
2) Apply psychological theories to analyze behavior (e.g., purchase behavior) and identify the needs of (prospective) customers in consumer and business markets
3) Design elements of the marketing mix—e.g., develop new products and set prices—in a way that creates long-term value
4) Create an effective and efficient marketing mix that attracts and engages customers, e.g., by running targeted promotions
5) Use quantitative methods and customer data to manage relationships with customers

Content

The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making.

The structure of the course will roughly follow the different steps of the value chain, i.e., the set of activities necessary for offering valuable products to customers. First, it will introduce students to psychological theories that help explain behavior, e.g., purchase behavior. It will also familiarize students with different methods from marketing research, which can be used to identify the needs of customers. Next, the course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing. A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

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

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

Literature


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

Taught competencies

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</table>

751-2205-00L Management for Enterprises in the Agri-Food-Chain II  W+  2 credits  2G  M. Weber

Abstract

Advanced Management in the Agri-Food Chain: Framework and models for management of organizations in the Agri-Food Chain in a complex environment

Objective

After the lecture the students ...

... know the characteristics and consequences of complexity in the organizational world,
... know and can apply selected comprehensive models for managing in complex situations,
... know possible practical applications and examples of the treated contents to organizations in the Agri-Food Chain and ... are able to deepen the relevant topics in an autonomous way.

Content

In the lecture the following contents will be treated:

- State, reasons and effects of complexity in the organizational world.
- A basic framework for shaping and governing intelligent organizations.
- Selected contemporary models for managing in the complex organizational world.
- Transfer and adaption of the models to organizations in the Agri-Food Chain.

Lecture notes / notice

Reader with selected contents.

Prerequisites / notice

- Vorlesung “Management für Unternehmen der Agrar- & Ernährungswirtschaft I” in D-USYS

Taught competencies

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Resource Economics and Agricultural Policy

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<td>751-2903-00L</td>
<td>Evaluation of Agricultural Policies</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>R. Huber, R. Finger, C. Schader</td>
</tr>
</tbody>
</table>

Abstract

In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.

Objective

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

Content

The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.
The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

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

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

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

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

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

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

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

Prerequisites /
notice
A detailed course schedule will be made available at the beginning of the semester.
During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

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

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and readings and slides will be available via Moodle.

Introduction to Sociology

International Aid and Development

Prerequisites: Basic knowledge of economics

Abstract

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

Objective

Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid. Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.

Content

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

Literature

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

International Environmental Politics

Prerequisites: Basic knowledge of economics

Abstract

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

Objective

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

Content

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

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

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

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

Lecture notes

Reading materials and slides will be available via Moodle.

Literature

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Prerequisites / notice

Number of participants limited to 25

Political Ecology of Food and Agriculture

Prerequisites: Basic knowledge of economics

Abstract

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

Objective

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

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

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

The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

Data has become an important resource in today's business environment, which can be used to make better management decisions. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.

In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created videos.

Literature

The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to that, there will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.

Prerequisites / notice

The course includes out-of-class assignments and projects to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups. Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.

Methodology Competences

Methods in Agricultural Economics

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<th>Type</th>
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<tr>
<td>363-0305-00L</td>
<td>Empirical Methods in Management</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Tillmanns</td>
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<tr>
<td>Abstract</td>
<td>In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created videos.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Literature</td>
<td>Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course includes out-of-class assignments and projects to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups. Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.</td>
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Intermediate Econometrics

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<tr>
<td>363-0585-00L</td>
<td>Intermediate Econometrics</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>G. Masllorens Fuentes</td>
</tr>
<tr>
<td>Abstract</td>
<td>The aim of the course is to discuss different econometric models and their empirical applications. We will cover cross-sectional linear and non-linear regression models, models for estimating treatment effects, and linear panel data models. By the end of the course, students should understand the different existing approaches, their applicability, and their advantages and disadvantages. They should be able to read and understand regression output tables. Additionally, students will be able to apply the estimation approaches in practice using STATA.</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 36 of 2345
In this class, students learn the basics of system dynamics and its application to agricultural and regional economic questions. In the theoretical part, we will discuss each estimation approach in detail. The lecture will present the assumptions, derivations, as well as the advantages and disadvantages of the estimation approach.

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

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

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

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

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

Literature

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites / Notice</th>
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<tbody>
<tr>
<td>751-0423-00L</td>
<td>Risk Analysis and Risk Management in Agriculture</td>
<td>3 credits</td>
<td>2 credits</td>
</tr>
<tr>
<td>751-1573-00L</td>
<td>Dynamic Simulation in Agricultural and Regional Economics</td>
<td>2 credits</td>
<td>2V</td>
</tr>
<tr>
<td>363-0541-00L</td>
<td>Systems Dynamics and Complexity</td>
<td>3 credits</td>
<td>3G</td>
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</table>

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

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

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

Prerequisites / Notice
knowledge of basic concepts of probability theory and microeconomics

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

Lecture notes
slides (will be provided during the class)

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

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

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

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

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

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

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


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

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

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**401-0647-00L**

**Introduction to Mathematical Optimization**

- **W 5 credits**
- **2V+1U**
- D. Adjaiashvili

**Objective**

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

**Content**

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

**Literature**

Information about relevant literature will be given in the lecture.

**Lecture notes**

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

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**363-0565-00L**

**Principles of Macroeconomics**

- **W 3 credits**
- **2V**
- J.-E. Sturm

**Objective**

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

**Content**

This course introduces the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems. This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

**Prerequisites / notice**

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

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**Lecture notes**


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

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concepts and Theories</strong></td>
<td><strong>Analytical Competencies</strong></td>
<td><strong>Communication</strong></td>
<td><strong>Adaptability and Flexibility</strong></td>
</tr>
<tr>
<td><strong>Techniques and Technologies</strong></td>
<td><strong>Decision-making</strong></td>
<td><strong>Cooperation and Teamwork</strong></td>
<td><strong>Creative Thinking</strong></td>
</tr>
<tr>
<td><strong>Media and Digital Technologies</strong></td>
<td><strong>Problem-solving</strong></td>
<td><strong>Customer Orientation</strong></td>
<td><strong>Critical Thinking</strong></td>
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<td><strong>Problem-solving</strong></td>
<td></td>
<td><strong>Leadership and Responsibility</strong></td>
<td><strong>Integrity and Work Ethics</strong></td>
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<tr>
<td><strong>Project Management</strong></td>
<td></td>
<td><strong>Self-presentation and Social Influence</strong></td>
<td><strong>Self-awareness and Self-reflection</strong></td>
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</table>

### Risk and Insurance Economics

**Abstract**

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

1. Individual decision making under risk
2. Models of insurance demand, risk sharing, insurance supply
3. Information issues in insurance markets
4. Advanced topics in microeconomics and behavioral economics
5. The macroeconomic role of insurers and insurance regulation

**Objective**

At the end of the course, the students will be able to:

- Understand the most common empirical methodologies used in environmental, energy, and resource economics;
- Understand the problems the methodologies learnt in class aim to address;
- Appreciate the importance of causal inference in empirical economics;
- Read and understand the research papers in the literature;
- Apply the empirical methods learnt in class using the software R.

**Literature**

Main literature:

- Handbook of the Economics of Risk and Uncertainty, Volume 1;

**Further readings**:

The course introduces students to empirical statistical methods that have wide application in environmental, energy, and resource economics and it is divided in four blocks. The first block is a quick review of the basic econometric methodology and concepts (OLS, standard errors, logit/probit models); the second block introduces demand models like the Almost Ideal Demand System, discrete choice models, and their evolutions; the third block explores causal inference in empirical economics and the main reduced-form econometric techniques used in policy evaluation, such as difference-in-differences, regression discontinuity and synthetic control; the fourth block introduces field experiments and instrumental variables, and their characteristics.

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

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

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

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

It is highly recommended to take 363-0570-00L Principles of Econometrics first.
### Socioeconomics of Agriculture

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-2903-00L</td>
<td>Evaluation of Agricultural Policies</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>R. Huber, R. Finger, C. Schader</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) They know the basics of how to design and implement a policy evaluation study. 3) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) They can critically assess the science-policy interface of policy evaluations.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Handouts and reading assignments</td>
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<tr>
<td><strong>Taught competencies</strong></td>
<td><strong>Subject-specific Competencies</strong>: Concepts and Theories assessed</td>
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<td></td>
<td><strong>Techniques and Technologies</strong>: assessed</td>
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<tr>
<td></td>
<td><strong>Method-specific Competencies</strong>: Analytical Competencies assessed</td>
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<tr>
<td></td>
<td><strong>Social Competencies</strong>: Cooperation and Teamwork assessed</td>
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<tr>
<td></td>
<td><strong>Personal Competencies</strong>: Critical Thinking assessed</td>
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### Dynamic Simulation in Agricultural and Regional Economics

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-2903-00L</td>
<td>Dynamic Simulation in Agricultural and Regional Economics</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>In this class, students learn the basics of system dynamics and its application to agricultural and regional economic questions. In the second half of the class, students develop their own simulation model, with which they evaluate potential interventions for improving the economic as well as the ecological sustainability of food systems.</td>
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</table>
| **Objective** | - Students learn the basic theory and practice of dynamic simulation.  
- Students can develop, analyze and extend a dynamic simulation model and interpret its results.  
- By applying the developed simulation model, students gain insights into food system issues. They also learn to recognize the benefits and pitfalls of dynamic simulation, both from a theoretical and an applied perspective. |
| **Lecture notes** | slides (will be provided during the class) |
| **Material** | see script | http://www.springer.com/gp/book/9783319741406 |
| **Prerequisites / notice** | Basic economic knowledge is expected. |
| **ECTS** | 2 |

### Management for Enterprises in the Agri-Food-Chain II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-2205-00L</td>
<td>Management for Enterprises in the Agri-Food-Chain II</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>M. Weber</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Advanced Management in the Agri-Food Chain: Framework and models for management of organizations in the Agri-Food Chain in a complex environment</td>
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</table>
| **Objective** | After the lecture the students ...  
... know the characteristics and consequences of complexity in the organizational world,  
... know and can apply selected comprehensive models for managing in complex situations,  
... know possible practical applications and examples of the treated contents to organizations in the Agri-Food Chain and ... are able to deepen the relevant topics in an autonomous way. |
| **Content** | In the lecture the following contents will be treated:  
- State, reasons and effects of complexity in the organizational world.  
- A basic framework for shaping and governing intelligent organizations.  
- Selected contemporary models for managing in the complex organizational world.  
- Transfer and adaption of the models to organizations in the Agri-Food Chain. |
| **Lecture notes** | Reader with selected contents. |
| **Prerequisites / notice** | Vorlesung “Management für Unternehmen der Agrar- & Ernährungswirtschaft I” in D-USYS |
| **Taught competencies** | **Subject-specific Competencies**: Techniques and Technologies assessed |
| | **Analytical Competencies**: Decision-making assessed  
**Problem-solving**: assessed |
| | **Social Competencies**: Communication assessed |
| | **Method-specific Competencies**: Cooperation and Teamwork assessed |
| | **Personnel Competencies**: Critical Thinking assessed |

### Socioeconomics of Agriculture

<table>
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</thead>
<tbody>
<tr>
<td>751-2903-00L</td>
<td>Socioeconomics of Agriculture</td>
<td>W</td>
<td>2 credits</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The main part of this lecture will examine constellations where hierarchies, markets or cooperation have been observed and described in the agricultural sector. On a more aggregated level, different agricultural systems will be evaluated in terms of main socioeconomic parameters like social capital or perceptions.</td>
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</tbody>
</table>
| **Content** | Students should be able to describe the dynamics of hierarchies, markets and cooperation in an agricultural context.  
Introduction to Sociology  
Introduction to Socioeconomics  
Agricultural Administration: Path dependencies and efficiency issues  
Power in the Chain  
The farming family  
Occupational Choices  
Consumption Choices  
Locational Choices  
Common Resource Management in Alpine Farming  
Agricultural Cooperatives  
Societal perceptions of agriculture  
Perceptions of farming from within  
Varieties of agricultural systems and policies |
| **Lecture notes** | http://www.springer.com/gp/book/9783319741406 |
| **Literature** | see script |
| **Prerequisites / notice** | Basic economic knowledge is expected. |
| **ECTS** | 3 |
### Risk Analysis and Risk Management in Agriculture

**Number**: 751-0423-00L  
**Title**: Risk Analysis and Risk Management in Agriculture  
**ECTS**: 3 credits  
**Lecturer**: R. Finger  
**Type**: R  
**Prerequisites / notice**: Knowledge of basic concepts of probability theory and microeconomics

#### Abstract
Agricultural production is exposed to various risks and risk management is indispensable. This course introduces modern concepts on farmers’ decision making under risk and risk management. We present innovative insights, empirical example from European agriculture. You gain hands-on experience using R.

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

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

#### Literature and readings
Lecture notes handouts will be distributed in the lecture and available on the moodle.

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### Empirical Methods in Management

**Number**: 363-0305-00L  
**Title**: Empirical Methods in Management  
**ECTS**: 3 credits  
**Lecturer**: S. Tillmanns  
**Type**: W  
**Prerequisites / notice**: Knowledge of basic concepts of probability theory and microeconomics

#### Abstract
In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created videos.

#### Objective
The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

#### Content
Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understand of statistical approaches. Therefore, this class introduces students to the world of empirical research and provides a practical understanding of statistical methods and their applications. In the area of quantitative research, students will learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like variance analysis will be incorporated in a standard statistical software package like SPSS or R.

#### Literature
Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.

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### International Aid and Development

**Number**: 851-0626-01L  
**Title**: International Aid and Development  
**ECTS**: 2 credits  
**Lecturer**: I. Günther  
**Type**: W  

#### Abstract
This course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups. Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.

#### Literature
Articles and book abstracts will be uploaded to the course website.

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### Agricultural Environment

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

#### Number

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>751-5101-00L</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>N. Buchmann, I. Feigenwinter, V. Klaus</td>
</tr>
</tbody>
</table>

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

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

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

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

Lecture notes
Handouts will be available in moodle.

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

Taught competencies

<table>
<thead>
<tr>
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<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td></td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Project Management</td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<td></td>
<td>assessed</td>
<td>not assessed</td>
<td>not assessed</td>
<td>Self-direction and Self-management</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>2 credits</td>
<td>2G</td>
<td>4 credits</td>
<td>4G</td>
</tr>
</tbody>
</table>

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

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

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

Lecture notes
Documents will be distributed during the lecture.

Literature
Documents will be distributed during the lecture.

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

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

Objective
Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small IsoProject, practice to search and analyze literature as well as to give an oral presentation.
Content

The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

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

Lecture notes

Handouts will be available on the webpage of the course.

Literature

Will be discussed in class.

Prerequisites / notice

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

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Problem-solving: not assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed

Personal Competencies
- Creative Thinking: assessed
- Self-direction and Self-management: not assessed

Agronomy and Plant Breeding

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

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

Animal Sciences

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

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-6001-00L</td>
<td>Forum: Livestock in the World Food System</td>
<td>W+</td>
<td>2</td>
<td>1S</td>
<td>S. Meese</td>
</tr>
<tr>
<td>Number of participants limited to 20.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.</td>
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</tr>
<tr>
<td>Objective</td>
<td>In the Forum &quot;Livestock in the World Food System&quot;, a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.</td>
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</tbody>
</table>
The Forum “Livestock in the World Food System” will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

Part 1

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

Part 2.

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

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

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

Abstract

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

Objective

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

Content

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

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

Abstract

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

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

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

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

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

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<td>751-3603-00L</td>
<td>Current Challenges in Plant Breeding</td>
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<td>Lecture notes</td>
<td>None</td>
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<td>Literature</td>
<td>Peer-reviewed research articles, selected according to the topic.</td>
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<tr>
<td>751-4811-00L</td>
<td>Alien Organisms in Agriculture</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>J. Collatz, M. Meissle</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course focuses on alien organisms in agriculture as well as the scientific assessment and regulatory management of their effects on the environment and agricultural production.</td>
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<tr>
<td>Objective</td>
<td>Students will understand the consequences arising from the unintentional or deliberate introduction of alien organisms into agricultural systems. They will be able to understand the concept of environmental risk assessment and be able to evaluate risk management options.</td>
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<tr>
<td>Content</td>
<td>Alien organisms in agriculture is a topic that receives an increasing awareness among farmers, agricultural scientists, regulators and the general public. Students of this course will learn about the nature of alien organisms such as invasive species, biocontrol organisms and genetically modified organisms. With a particular focus on arthropods, plants and their interactions we will look at the potential threats the novel organisms pose, the benefits they provide and how both of these effects can be scientifically assessed. Students will learn how the topic of alien organisms in agriculture is intrinsically tied to policy making and regulation and get to know current examples and future challenges in research. In the last part of the course students will be able to apply the acquired knowledge in a practical exercise (case study).</td>
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<tr>
<td>Lecture notes</td>
<td>Material will be distributed during the course</td>
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<tr>
<td>Prerequisites / notice</td>
<td>A part of the course will take place in flipped classroom mode, i.e. the lectures on 27.9., 18.10., 25.10., 15.11. and 22.11. will be available as podcasts.</td>
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<tr>
<td>751-5101-00L</td>
<td>Biogeochemistry and Sustainable Management</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>N. Buchmann, I. Feigenwinter, V. Klaus</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems. Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems, be able to analyze large meteorological and flux data sets, and evaluate the impacts of weather events and management practices, based on real-life data. Moreover, students will be able to coordinate and work successfully in small (interdisciplinary) teams.</td>
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</tbody>
</table>
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

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

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

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>Taught competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystems. The seminar is composed by presentations of experts and of the students. The presentations will be synthesized during a final discussion.</td>
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</tr>
<tr>
<td>Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.</td>
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<tr>
<td>Handouts will be available in moodle.</td>
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</table>

**751-5115-00L Current Aspects of Nutrient Cycle in Agro-Ecosystems**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
<th>Taught in English.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
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<td></td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Project Management</td>
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<tr>
<td>Problem-solving</td>
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<td></td>
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<tr>
<td>Communication</td>
<td>Customer Orientation</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>Leadership and Responsibility</td>
<td>Creative Thinking</td>
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</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
<td>Critical Thinking</td>
<td></td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Negotiation</td>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<td>Self-awareness and Self-reflection</td>
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<tr>
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<td></td>
<td>Self-direction and Self-management</td>
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**751-4003-01L Current Topics in Grassland Sciences (HS)**

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<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
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</table>
Identification based on host, symptoms and micro-morphology, completed with life cycles and related control measures of the most important fungal diseases and their causal pathogens of annual and perennial crops with agricultural significance.

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

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

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

The course will be in German (spec. nomenclature)

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

Method-specific Competencies
- Analytical Competencies: not assessed
- Problem-solving: not assessed
- Critical Thinking: not assessed

Crop Health

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

Number of participants limited to 20.

Number of participants limited to 30.

Teaching language: German.

Number of participants limited to 20.

Number of participants limited to 30.

Teaching language: German.
# Data Science and Technology for Agricultural Science

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>701-3001-00L</td>
<td>Environmental Systems Data Science: Data Processing</td>
<td>W+</td>
<td>2 credits</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne, M. Volpi</td>
</tr>
</tbody>
</table>

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

**Note:** This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

## Abstract

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

## Objective

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

## Prerequisites / notice

- 252-0840-02L  Anwendungsnahes Programmieren mit Python
- 401-0624-00L  Mathematik IV: Statistik
- 401-6215-00L  Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L  Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L  Mathematik VI: Angewandte Statistik für Umwelt- naturwissenschaften

## Lecture notes

- An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf
- Lecture notes
- The course resources will be provided via the Moodle web learning platform.

## Prerequisites / notice

- As from FS 2019, subscribing via Mystudies should *automatically* make you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=15518

### 401-6215-00L Using R for Data Analysis and Graphics (Part I)

**Abstract**

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

**Objective**

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

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

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

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

## Preparations

- Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

### 401-6217-00L Using R for Data Analysis and Graphics (Part II)

**Abstract**

The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

**Note:** This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.
The students will be able to use the software R efficiently for data analysis, graphics and simple programming. The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is a free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

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

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

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

Basic knowledge of R equivalent to "Using R ... (part 1)" ( = 401-6215-00L ) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribes via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=15522

<table>
<thead>
<tr>
<th>751-5510-00L</th>
<th>Introduction to Agricultural Robotics</th>
<th>W+</th>
<th>3 credits</th>
<th>2G</th>
<th>S. Mintchev</th>
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</table>

Abstract
Autonomous robots are quickly becoming a key player in the transition to precision agriculture. In this course, students will learn theoretical and practical aspects of robotics. Lectures will introduce how robots operate and analyse their application to precision agriculture. In hands-on laboratories, students will apply concepts learned in class on educational robots to simulate a weeding task.

Objective
After the course, students will be able to critically examine and select appropriate robotic solutions for agricultural applications. The learning objectives of the course are: (i) illustrate the principle of operation of the main components of a robotic system, (ii) analyse how the different robotic components are integrated and contribute to the functioning of a robotic system, and (iii) solve problems in the field of agriculture using robotic principles.

Content
Robots are becoming a key technology in the transition to smart farming and in supporting the agricultural needs of the 21st century. For example, robots enable site-specific fertilization, automated weeding, or livestock herding. The course gives an overview of robotic systems, beginning with their fundamental components (e.g., sensors, actuators, locomotion strategies) and gradually scaling up to the system level, illustrating the concepts of perception, robot control, obstacle avoidance and navigation. Exercises performed with an educational robot (Thymio) will complement the theoretical lectures providing a hands-on practical experience of the challenges of using these machines. During the course, students will gradually apply the theoretical and practical knowledge they are learning. To this end, students will work in teams to develop a robotic solution for an agricultural task of their choice. Students will learn to translate the task into meaningful requirements for a robotic system and critically select the most appropriate components to achieve the required robotic functions. Students will periodically present and discuss the development of this "robot design" exercise during presentations and in a journal report.

Lecture notes
Literature
Copies of the slides and exercises will be provided on the course Moodle page.


Prerequisites / notice
No mandatory prerequisites, but it is preferable that students have a basic knowledge of computer programming.

Class size limitation to 30 students.

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<tr>
<th>Taught competencies</th>
<th>Competencies and Theories</th>
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<td>Method-specific Competencies</td>
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<table>
<thead>
<tr>
<th>701-0951-00L</th>
<th>GIS - Introduction into Geoinformation Science and Technology</th>
<th>W+</th>
<th>5 credits</th>
<th>2V+3P</th>
<th>M. A. M. Niederhuber</th>
</tr>
</thead>
</table>

Abstract
Theoretical basics and fundamental concepts of Geographic Information Science (GIS) are imparted and subsequently further elaborated with the software ArcGIS. At the end, the students will be able to independently solve basic realistic GIS problems.
Objective
Students are able to
- elucidate the theoretical and conceptional foundations of geographic information systems (GIS)
- independently perform normal GIS work using commercial software and practical examples

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

Literature

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

701-3003-00L Environmental Systems Data Science: Machine Learning
Number of participants is limited to 80.
Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

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

Waiting list will be deleted on 30.09.2022

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

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

Literature

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

Functioning of Soil Systems

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

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

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

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

*W* 4 credits 4G

E. Frossard, L. P. Schönholzer, M. Wiggenhauser

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

*W* 2 credits 2G

R. A. Werner, N. Buchmann, A. Gessler, M. Lehmann

### Lecture notes/Literature
Documents will be distributed during the lecture.

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

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

Students must have visited the plant nutrition lectures in the 3rd and 6th semesters and the lecture pedosphere in the 3rd semester of the agricultural study program of the ETH (or bring an equivalent knowledge). This knowledge is indispensable for this 7th semester.

### Taught competencies
Subject-specific Competencies

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Method-specific Competencies

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### Autumn Semester 2022

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Date: 18.08.2022 12:39  Autumn Semester 2022  Page 52 of 2345
Abstract
This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

Objective
Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small IsoProject, practice to search and analyze literature as well as to give an oral presentation.

Content
The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

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

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

Literature
Will be discussed in class.

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

Taught competencies
Subject-specific Competencies: Concepts and Theories - assessed, Techniques and Technologies - assessed
Method-specific Competencies: Analytical Competencies - assessed, Problem-solving - not assessed, Project Management - assessed, Social Competencies: Communication - assessed
Personal Competencies: Creative Thinking - assessed, Self-direction and Self-management - not assessed

701-0533-00L Soil and Water Chemistry W 3 credits 2G R. Kretzschmar, D. I. Christl, L. Winkel
Abstract
This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.

Objective
1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants.
2. Quantitative applications of chemical equilibria to processes in natural systems.

Content
Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

Lecture notes
Lecture slides on Moodle

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

Prerequisites / notice
The lecture courses Pedosphere and Hydrosphere are highly recommended.

Taught competencies
Subject-specific Competencies: Concepts and Theories - assessed, Techniques and Technologies - assessed
Method-specific Competencies: Analytical Competencies - assessed, Problem-solving - assessed

701-0535-00L Environmental Soil Physics/Vadose Zone Hydrology W 3 credits 2V+1U A. Carminati, P. U. Lehmann Grunder
Abstract
The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

Objective
Students are able to
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils
Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid, liquid and gaseous phases; soil water content; soil texture; particle size distributions;

Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure

Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab

Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, and capillary rise); units and calculations and measurement of equilibrium soil water potential components

Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab

Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)

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

Week 8: Numerical solution of Richards equation – using Hydrus1D for simulation of unsaturated flow; choosing class project

Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow

Week 10: Root water uptake and transpiration

Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 12: Summary of lectures; solution of old exam

Week 13: Written semester-end exam

Week 14: Short presentations of Hydrus class projects; discussion of written exam

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

701-1343-00L Soil-Plant Water Relations 3 credits 2V A. Carminati

751-5201-10L Tropical Cropping Systems, Soils and Livelihoods 5 credits 2G J. Six, K. Benabderrazik

Objective

Abstract

Content

Literature

Prerequisites / notice

W+ 3 credits

2G

Notice

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 54 of 2345
Content

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

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

Prerequisites / notice

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

Taught competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies

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

Personal Competencies

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

General Crop Science

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

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<th>Number</th>
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<tr>
<td>751-4104-00L</td>
<td>Alternative Crops</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Walter, K. Berger Büter</td>
</tr>
<tr>
<td>Abstract</td>
<td>Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.</td>
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<tr>
<td>Objective</td>
<td>During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.</td>
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<tr>
<td>751-3603-00L</td>
<td>Current Challenges in Plant Breeding</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>B. Studer, A. Hund, R. Kölliker</td>
</tr>
<tr>
<td>Abstract</td>
<td>The seminar 'Current challenges in plant breeding' aims to bring together national and international experts in plant breeding to discuss current activities, latest achievements and future prospective of a selected topic/area in plant breeding.</td>
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<tr>
<td>Objective</td>
<td>The educational objectives cover thematic, methodic as well as social and personal competencies: Thematic/methodic competencies: - Deepening of scientific knowledge in plant breeding - Critical evaluation of current challenges and new concepts in plant breeding - Promotion of collaboration and Master thesis projects with practical plant breeders Social/personal competencies: - Independent literature research to get familiar with the selected topic - Critical evaluation and consolidation of the acquired knowledge in an interdisciplinary team - Establishment of a scientific presentation in an interdisciplinary team - Presentation and discussion of the teamwork outcome - Establishing contacts and strengthening the network to national and international plant breeders and scientist</td>
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<tr>
<td>Content</td>
<td>Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).</td>
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<tr>
<td>Lecture notes</td>
<td>None</td>
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<tr>
<td>Literature</td>
<td>Peer-reviewed research articles, selected according to the topic.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Participation in the BSc course 'Pflanzenzüchtung' is strongly recommended, a completed course in 'Molecular Plant Breeding' is advantageous.</td>
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<tr>
<td>751-4704-00L</td>
<td>Weed Science</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>B. Streit, U. J. Haas</td>
</tr>
<tr>
<td>Abstract</td>
<td>Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.</td>
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<tr>
<td>Objective</td>
<td>At the end of the course the students are qualified to develop sustainable solutions for weed problems in agricultural and natural habitats. Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.</td>
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<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
</tr>
<tr>
<td>Abstract</td>
<td>This is an introductory class on insect ecology. During the course you will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes lectures, small group discussions and outside readings.</td>
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<tr>
<td>Objective</td>
<td>The aim of the course is to gain an understanding of how insects have specialised and adapted to occupy diverse environmental niches and become vital to ecosystem processes. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutualistic and parasitic interactions and examining insect ecology in an evolutionary context.</td>
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<tr>
<td>Lecture notes</td>
<td>Provided to students through Moodle</td>
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<tr>
<td>Literature</td>
<td>Selected required readings (peer reviewed literature). Optional recommended readings with additional information.</td>
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</tbody>
</table>
Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

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

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

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

Literature
Papers will be assigned and downloaded from a web page announced during the lecture.
The course discusses the mechanistic relationships between nutrient speciation in fertilizer and nutrient uptake by plants using phosphorus as an example. The course involves theoretical aspects of nutrient cycling, laboratory work, data analysis and presentation, and the use of advanced methods in plant nutrition studies.

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

Documents will be distributed during the lecture.

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

The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

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

Handouts will be available on the webpage of the course.

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

The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is “Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments”.

Analyze publications and/or data records on long-term field experiments regarding their content on integrated nutrient management and derive the nutrient use efficiency; link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.
This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field concepts and theories, analytical competencies, decision-making skills, and problem-solving abilities.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>Analytical Competencies</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>Decision-making</td>
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</table>

**751-4003-01L Current Topics in Grassland Sciences (HS)**

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<td>Adaptability and Flexibility</td>
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</table>

**751-5201-10L Tropical Cropping Systems, Soils and Livelihoods (with Excursion)**

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<th>Method-specific Competencies</th>
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<td>Social Competencies</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>Decision-making</td>
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</tbody>
</table>

**Prerequisites / notice**

- Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.
- Lectures notes: none
- Important: Students who enroll for this course are strongly recommended to verify with lecturers from other courses whether their absence of two weeks may affect their performance in the respective courses.
- On the second module, students gain practical knowledge on field - An integral part of the course is the two-week field project in Kenya, conducting various assessments related to Food and Energy Security.

**MOTIVATION TO ENROLL TO THIS CLASS. A SELECTION OF 20 STUDENTS WILL BE DONE ON THE BASIS OF THE LETTERS.**

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

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<th>Social Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Leadership and Responsibility</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Creative Thinking</td>
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<td></td>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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### 751-2105-00L  
**Political Ecology of Food and Agriculture**

**Number of participants limited to 25**

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


Deadline for the application is 10th September 2022. Selection made until 16th September. Questions regarding the application to johanna.jacobi@usys.ethz.ch.

**Abstract**

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

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

**Content**

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

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

**Literature**

Library list provided on Moodle.


### Taught competencies

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<td>Self-direction and Self-management</td>
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### Non-Ruminant Science

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

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

**Abstract**

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

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

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

Prerequisites / notice
Examination:
- Examination Part 1: Graded written examination (1 hour) on the material covered.
- Examination Part 2: Graded semester performance completed during the block course.

Part 1 and 2 contribute equally to the final grade.

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

| Number of participants limited to 20. |

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

Objective
In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society).

The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.

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

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

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

Lecture notes
no scriptum

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

Feedback on the presentation style of a student

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

| Does not take place this semester. |

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

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

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


Pathologische Veränderungen werden Präparationsartefakten gegenübergestellt und somit eine kritische Bewertung von Beurteilungen aufgrund morphologischer Kriterien vorgenommen.


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

In der Nachbereitung zum Praktikum wird ein Bericht angefertigt, in dem die Vorgehensweise (Verfahrensprotokoll), die Befunde (Ergebnisprotokoll) und die kritische Auseinandersetzung mit den Inhalten des Praktikums (kritische Beurteilung) dokumentiert werden.
Principles of Livestock Systems
This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can no longer be chosen. The course units offered in the minor can still be taken as electives.

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>751-6243-00L</td>
<td>Breeding and Conservation of Animal Genetic Resources</td>
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<td>Abstract</td>
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<td>Animal genetic resources refer to the genetic and species diversity of livestock. Only a few production breeds have been further developed through breeding, while local breeds have no longer been able to survive in this competition. Without the support of endangered breeds and the sustainable breeding of productive breeds, many regionally typical breeds are threatened with extinction.</td>
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<td>Objective</td>
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<td>Learning Objectives: Part 1:</td>
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<td>At the end of the course, students are able to assess the importance and problems of small ruminant breeding and husbandry in Switzerland and neighbouring countries. They know the most important breeding objectives and are able to assess them in terms of production and sustainable development in small ruminants and cattle.</td>
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<td>Learning objectives part 2:</td>
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<td></td>
<td>The second part gives an overview of the distribution, endangerment and conservation of breed diversity of farm animals in Switzerland and internationally. The theory is illustrated with numerous examples and the knowledge is deepened in exercises.</td>
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<tbody>
<tr>
<td>751-6217-00L</td>
<td>Practical Course in Microscopy of Functional Histology</td>
<td>W</td>
<td>3 credits</td>
<td>6P</td>
<td>not available</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Die &quot;Funktionelle Histologie&quot; beschreibt die histologischen und zytologischen Strukturen mit ihren jeweiligen Aufgaben und Wechselwirkungen innerhalb ausgewählter Organsysteme. Die endokrinologisch relevanten Organe und deren Präparation werden am Beispiel des Rindes kennengelernt.</td>
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<td>Content</td>
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<td>Jeder/m Studierenden wird ein Organ zugeteilt, mit welchem sie/er sich intensiv theoretisch und praktisch auseinandersetzt. Anhand dieses Organes als rotem Faden, welches vom Schlachthof bereitgestellt und von den Studierenden selber seziiert, eingebettet, geschnitten, gefärbt und mikroskopiert wird, werden die Lernziele erreicht.</td>
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<tbody>
<tr>
<td>751-6129-00L</td>
<td>Practical Course Epigenetics</td>
<td>W</td>
<td>3 credits</td>
<td>6P</td>
<td>not available</td>
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<td></td>
<td>Abstract</td>
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<td>The practical course will comprise of lecture elements introducing the topic of epigenetics and a large amount of practical work where you will be able to perform DNA methylation analyses on your own. In particular, we will focus on DNA extraction and the estimation of global and local DNA methylation.</td>
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<td>Objective</td>
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<td>The competencies and aims for the course are: Get first hands-on experience with the experimental techniques. Answer a scientific question by conducting experiments. Obtain results of an experiment and get insight into what affects technical variation and thus influences reproducibility. Interpret results in an adequate manner to solve a scientific question. Combine results to draw an adequate conclusion. Present a research paper on epigenetics.</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<td>You will receive in advance a selection of research papers, a document with the theoretical background of the techniques included in the course, the slides of the lessons in pdf and a detailed protocol of the work we will do.</td>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-6305-00L</td>
<td>Livestock Breeding and Genomics</td>
<td>W+</td>
<td>3 credits</td>
<td>3G</td>
<td>P. von Rohr</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Swiss routine breeding value estimation/genetic evaluation systems of cattle, pig, sheep and goats are presented with methods and evaluated traits. Examples will be demonstrated using the statistical software R.</td>
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</tbody>
</table>
Ruminal Digestion

ECTS
To be announced in the lectures.

M. Terranova, U. Witschi

Title
Lecturers

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

- an own short lecture
- a final oral examination with focus on comprehension of the fundamental linkages rather than of specific details

751-6113-00L
Endocrinology and Biology of Reproduction

W+ 3 credits 2G S. E. Ulbrich, S. M. Bernal Ulloa

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

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

Objective
Die Studierenden erlangen das grundlegende theoretische Verständnis und Fachwissen zur Endokrinologie der Reproduktion und zur weiblichen und männlichen Reproduktionsbiologie. Sie können darüber hinaus pathologische Situationen (Fortpflanzungsstörungen) und deren vielfältige Ursachen in den physiologischen Kontext einordnen.

Ruminant Science

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

Objective
The students know the theoretical and practical application of breeding value estimation in Switzerland for cattle, pig, sheep and goats. The students are able to interpret estimated breeding values.

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

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

Literature
To be announced in the lectures.

Number  Title Type ECTS Hours  Lecturers
751-6501-00L Ruminant Science W 4 credits 4G M. Niu, M. Terranova, U. Witschi

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

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

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

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

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

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

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

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

751-7211-00L Ruminial Digestion W 1 credit 1G not available

Abstract
Does not take place this semester.

Objective
This course broadens the knowledge in one of the most important aspects of ruminant nutrition: the microbial digestion in the rumen (and in the hindgut). For a comprehensive understanding of the rumen microbial ecosystem, the mechanisms of nutrient fermentation and the synthesis of microbial protein, thorough basics are provided. Apart from lectures, group and laboratory exercises are included. The course enables students to understand in detail how ruminal digestion works and how this knowledge can be applied to design optimal feeding diets using highly fibrous forages and a variety of other feeds. The students also are able to show how to modify the most important rumen microbes beneficially by nutritional means.
Breeding and Conservation of Animal Genetic Resources refer to the genetic and species diversity of livestock. Only a few production breeds have been further developed.

In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and will be communicated at the start of the course.

S. Meese

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

Part 1

Objective

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

The theory is illustrated with numerous examples and the knowledge is deepened in exercises.

Learning Objectives: Part 1:

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

Learning objectives part 2:

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

Requirements for allocation of the two credit points:

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

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

Aspect 1 - Oral presentation: The students form small groups and are lecturers.

Aspect 2 - chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion.

Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

Part 2

Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.

Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

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

Lecture notes provided via Moodle.

Will be communicated at the start of the course.

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

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

751-6001-00L  Forum: Livestock in the World Food System  W  2 credits  1S  S. Meese

Number of participants limited to 20.

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

In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society).

The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.

751-6243-00L  Breeding and Conservation of Animal Genetic Resources  W  2 credits  2V  H. Signer-Hasler, S. Neuenschwander

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

Learning Objectives: Part 1:

Learning objectives part 2:

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

学生应掌握食品和饲料中的不同生物活性成分。本课程涵盖了食品成分的营养学方面。

2V

营养和食品组成

J. M. Sych

实际文献将会提供

课程目标

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

国际参考文献和书籍

Other references on the websites of J. M. Sych and P. Krütli. A selection of literature will be made available on the website.

Prerequisites / notice

Students should have a basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

Sustainable Agricultural Development

The minor Transdisciplinary for Sustainable Development was revised and renamed for the academic year 22/23. The course units that were previously offered are still part of the Sustainable Agricultural Development minor.

课程目标

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

国际参考文献和书籍

Some contents will be provided by registered students who will present as a group an actual publication.

Prerequisites / notice

Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.

Sustainable Agricultural Development

The minor Transdisciplinary for Sustainable Development was revised and renamed for the academic year 22/23. The course units that were previously offered are still part of the Sustainable Agricultural Development minor.

课程目标

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

国际参考文献和书籍

Some contents will be provided by registered students who will present as a group an actual publication.

Prerequisites / notice

Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.

Sustainable Agricultural Development

The minor Transdisciplinary for Sustainable Development was revised and renamed for the academic year 22/23. The course units that were previously offered are still part of the Sustainable Agricultural Development minor.

课程目标

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

国际参考文献和书籍

Some contents will be provided by registered students who will present as a group an actual publication.

Prerequisites / notice

Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.
Abstract

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

Objective

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

Content

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

Lecture notes

Handouts are provided

Literature

Selected scientific articles and book-chapters

Prerequisites / notice

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

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>not assessed</td>
<td>assessed</td>
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751-2105-00L

Political Ecology of Food and Agriculture

Number of participants limited to 25

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

Upload your application on Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=17604

Deadline for the application is 10th September 2022. Selection made until 16th September. Questions regarding the application to johanna.jacobi@usys.ethz.ch.

Abstract

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

Objective

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

Content

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

Literature

Literature list provided on Moodle.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Communication</td>
<td>Adaptable and Flexible</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Cooperation and Teamwork</td>
<td>Negotiation</td>
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751-5003-00L

Sustainable Agroecosystems II

This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation (1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).
The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) in both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management). The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholders in the food system in order to support a sustainable transformation.

### Literature


### Prerequisites / notice

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

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<tr>
<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<tr>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Sensitivity to Diversity</td>
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<tr>
<td>assessed</td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>assessed</td>
<td>Self-direction and Self-management</td>
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<td>assessed</td>
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</table>

### Objective

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

### Requirements for allocation of the two credit points:

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

### Content

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

### Abstract

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

### Literature

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

### Prerequisites / notice

- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies
-Taught
-Competencies
-Prerequisites

### Literature

- International Aid and Development
  - 851-0626-01L
  - 2 credits
  - W+ 2V
  - I. Günther

- Forum: Livestock in the World Food System
  - 751-6001-00L
  - 2 credits
  - W+ 1S
  - S. Meese

- Tropical Cropping Systems, Soils and Livelihoods (with Excursion)
  - 751-5201-10L
  - 5 credits
  - W+ 2G
  - J. Six, K. Benabderrazik

### Abstract

This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, Resilience to Soil physics.

### Lecture notes

- no script
- Requirements for allocation of the two credit points:
  - oral talk with sufficient handout
  - delivery of the scientific writing in sufficient quality
  - active participation during all presentations (in case of absence there will be additional tasks)
  - Feedback on the presentation style of a student

### Data:

- 18.08.2022 12:39
- Autumn Semester 2022
- Page 66 of 2345
This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, resilience to soil physics or agricultural economics. Students will engage in readings, discussions and exchanges on the specifics of tropical agriculture.

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

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

**Prerequisites / notice**

**Taught competencies**

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

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Problem-solving: assessed
  - Project Management: assessed

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Leadership and Responsibility: assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: assessed
  - Negotiation: not assessed

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

- **Electives Courses**

  Elective courses can be chosen from the entire course programme of the ETH Zurich as well as from the course programme of the University of Zurich.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>701-3001-00L</td>
<td>Environmental Systems Data Science: Data Processing</td>
<td><strong>Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.</strong></td>
<td>W+</td>
<td>2 credits</td>
<td>2G</td>
</tr>
</tbody>
</table>

Number of participants is limited to 80.

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

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

Waiting list will be deleted on 30.09.2022

Abstract

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

Objective

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

Content

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

Prerequisites / notice

- 252-0840-02L Anwendungsnahes Programmieren mit Python
- 401-0624-00L Mathematik IV: Statistik
- 401-6215-00L Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

751-5510-00L Introduction to Agricultural Robotics

Abstract

Autonomous robots are quickly becoming a key player in the transition to precision agriculture. In this course, students will learn theoretical and practical aspects of robotics. Lectures will introduce how robots operate and analyse their application to precision agriculture. In hands-on laboratories, students will apply concepts learned in class on educational robots to simulate a weeding task.
Objective
After the course, students will be able to critically examine and select appropriate robotic solutions for agricultural applications. The learning objectives of the course are: (i) illustrate the principle of operation of the main components of a robotic system, (ii) analyse how the different robotic components are integrated and contribute to the functioning of a robotic system, and (iii) solve problems in the field of agriculture using robotic principles.

Content
Robots are becoming a key technology in the transition to smart farming and in supporting the agricultural needs of the 21st century. For example, robots enable site-specific fertilization, automated weeding, or livestock herding. The course gives an overview of robotic systems, beginning with their fundamental components (e.g., sensors, actuators, locomotion strategies) and gradually scaling up to the system level, illustrating the concepts of perception, robot control, obstacle avoidance and navigation. Exercises performed with an educational robot (Thymio) will complement the theoretical lectures providing a hands-on practical experience of the challenges of using these machines.

During the course, students will gradually apply the theoretical and practical knowledge they are learning. To this end, students will work in teams to develop a robotic solution for an agricultural task of their choice. Students will learn to translate the task into meaningful requirements for a robotic system and critically select the most appropriate components to achieve the required robotic functions. Students will periodically present and discuss the development of this "robot design" exercise during presentations and in a journal report.

Lecture notes
Copies of the slides and exercises will be provided on the course Moodle page.

Literature

Prerequisites / notice
No mandatory prerequisites, but it is preferable that students have a basic knowledge of computer programming.

Class size limitation to 30 students.

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity

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

W+ 2 credits 2G M. Sonneveld, N. Buchmann

Agroecology (HS)

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

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

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

Content
The course is designed as a combination of a series of five public lectures/webinars on "Agroecology in the transition to sustainable food systems" delivered by national and international scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a debate format. The public lectures bring different perspectives to the discussion and are intended to fuel the students debates in the second part of each course. Each of these debates revisits one of the thirteen principles of agroecology. Each debate which is organised in form of a role play will involve different groups of students taking on roles of various food system actors. All groups will synthesize their discussions in a short report.

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

Literature

Report of HLPE on agroecology:

Master’s Thesis

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

751-5005-00L

Agroecology (HS)

W+ 2 credits 2G M. Sonneveld, N. Buchmann

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

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

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

Content
The course is designed as a combination of a series of five public lectures/webinars on "Agroecology in the transition to sustainable food systems" delivered by national and international scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a debate format. The public lectures bring different perspectives to the discussion and are intended to fuel the students debates in the second part of each course. Each of these debates revisits one of the thirteen principles of agroecology. Each debate which is organised in form of a role play will involve different groups of students taking on roles of various food system actors. All groups will synthesize their discussions in a short report.

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

Literature

Report of HLPE on agroecology:

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

Master’s Thesis

Number Title Type ECTS Hours Lecturers

751-1030-00L Master’s Thesis

0 30 credits 64D Lecturers

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;

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b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
The Master thesis is an independent scientific work. Normally the subject is selected among the topics of the core subject. It is written under the guidance of a agricultural science professor.

Objective
The independent writing of a scientific paper/thesis

<table>
<thead>
<tr>
<th>Agricultural Sciences Master - Key for Type</th>
<th>W+</th>
<th>Compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td></td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td></td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td></td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td></td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td></td>
<td>Suitable for doctorate</td>
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</table>

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

ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
### Applied Geophysics Master

*Courses at ETH Zurich only take place in Spring Semester.*

#### Applied Geophysics Master - Key for Type

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

#### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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</thead>
<tbody>
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<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

#### ECTS

- **European Credit Transfer and Accumulation System**
- Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0603-00L</td>
<td>Structural Design I</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>P. Block, J. Schwartz</td>
</tr>
</tbody>
</table>
| **Abstract** | Determination of internal forces and description of structural behaviour of mixed arches and cable structures, of truss systems, beams, slabs, panels and frames using method of graphical statics as well as dimensioning of these structural systems. Structural behaviour of columns. Discussion of reference buildings and illustration of interplay of structural system and architectural intention.  
Objective | Awareness of the most important structural systems. Understanding of the interplay of load and form. Estimation of the inner forces and dimensioning of elements.  
Content | After a general introduction of basic concepts, structural systems such as cable and arch structures will be analyzed with the help of graphic statics. The students will learn to understand the flow of forces in a structural system in relation to the system's form. They will be able to modify this force flow and give dimension to the structural components.  
Lecture notes | All concepts, approaches and methods will be introduced in the weekly lectures and practiced in subsequent exercises.  
"Rule of thumb structural design" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2013, ISBN: 978-3-421-03904-0)  
Further learning material:  
| 052-0703-00L | Sociology I | O    | 2 credits | 2V    | C. Schmid, I. Apostol, N. Bathla, A. Hertzog-Fraser |
| **Abstract** | Sociology I investigates the relation between social developments and the production of the built environment from a macro-sociological point of view. It examines central aspects of social change, historical and contemporary forms of urbanization, and typical examples of models of urbanization.  
Objective | Sociology I deals with the macro-sociological point of view, and investigates the relation between social developments and the production of the built environment. In the first part central aspects of social change are examined, in particular the transition from Fordism to Neoliberalism and the interlinked processes of globalization and regionalization. The second part deals with historical and current forms of urbanization. Among other aspects, it focuses on the changed significance of the urban-rural contradiction, the processes of suburbanization, periurbanization, and planetary urbanization; the formation of global cities and metropolitan regions; the development of new urban configurations in centres (gentrification) and in urban peripheries (edge city, exopolis, new urban intensity). In the third part these general processes are illustrated by typical models of urbanization: Manchester, Chicago, Los Angeles, Paris and Zürich.  
Literature | A detailed collection of original texts will be distributed. |
| 052-0901-00L | Building History I | O    | 2 credits | 2V    | S. Holzer |
| **Abstract** | History of building from classical antiquity to modernity: building types, constructions, forms, with particular reference to functional issues such as flexibility of use, statics, durability. This is not a mere history lecture, but an important part of the basic introduction into construction.  
Objective | Participants know the fundamentals of building history, including landmark monuments of each era, key historic constructions and forms. They are able to "read" a historic building and to relate it to building history. They are aware of the variety of historic building constructions.  
Content | Building History I covers the period from classical Greek antiquity to Gothic architecture. The principal topics include construction issues such as Greek megalithic building, Roman mortar-and-rubble construction, and Gothic rationalism of vaulted architecture.  
Within the Vitruvian and Albertian triad of firmitas, utilitas and venustas, we focus on the first two topics, whereas the last topic (deciphering the "meaning" of architecture) stands at the heart of the "architectural history" lectures. The present lecture contributes essentially to deepening knowledge about historic constructions, an indispensable precondition for building within existing fabric.  
Lecture notes | Please keep a tight record of manuscript notes yourself. Lecture notes to some topics will be provided. pdf of lecture slides will be on line before each lecture.  
Literature | Will be announced during the lectures. |
Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0803-00L</td>
<td>History and Theory of Architecture I</td>
<td>O</td>
<td>2</td>
<td>2+2</td>
<td>M. Delbeke, T. Avermaete, L. Stalder, P. Ursprung</td>
</tr>
</tbody>
</table>

Abstract

Introduction and overview of the history and theory of architecture from the Renaissance to the nineteenth century. The course covers the chronology and key works, protagonists and discourses of early modern European architecture. ‘Fundamentals for the History and Theory of Architecture I-II’ provides a practical introduction to the methods and instruments of the history of art and architecture.

Objective

1. Acquiring basic knowledge of the history and theory of architecture during the early modern period, of its key protagonists and discourses and of the methods and instruments of architectural research.
2. Identifying the main architectural issues and debates of the period and recognising the places and architectural works covered in the course.
3. Acquiring the tools to develop a historically informed reading of the built environment, recognising debates, styles, ideas and problems which drive and inform architectural production.
4. Developing the tools to draw on historical, theoretical and critical research to the benefit of one’s own architectural culture.

Content

The course ‘History and Theory of Architecture I-II’ offers a chronological and thematic survey of early modern architecture and architectural theory produced in Europe from the 15th to 19th century. The course is based on thematic lectures, analysing key European architectural works, texts and iconography. Themes will include the origin of the Vitruvian tradition in architectural theory and practice and its dissemination in Italy during the 15th and 16th centuries; the mediatisation of architectural principles through the development of book production during the 16th century; the development of divergent theories of architectural composition and design in Italy and France between the 16th and 17th centuries; the formation and international spread of religious symbolism through architecture; analyses of original design practices, such as in the case of Michelangelo; a study of building types, such as the palazzo and the villa, and their codification by architects like Andrea Palladio; debates over questions of beauty and ornament, especially in the 17th and 18th centuries; questions of patronage and the relationship between architecture and political and religious powers (e.g. the French Monarchy and the Roman Papacy); the relation between buildings and their urban setting in the development of European capitals like Rome, Paris and Berlin; historicism and attitudes towards the past in architectural styles.

In addition to the main lectures, the course ‘History and Theory of Architecture I-II’ will also include a series of seminars, called ‘Small Narratives’. These seminars are meant to widen the scope of the programme by exploring case studies, such as buildings and ruins in Zurich, which relate and contribute to the content of the course. While content of the ‘Small Narratives’ seminars is not part of the exam, students are invited to make use of it for their study, and attendance is compulsory.

The course ‘Fundamentals of the History and Theory of Architecture I-II’ aims to explore and develop basic methods and strategies to research the history of art and architecture. It consists of four parts, each developed under one of the four Chairs of the gta, and each dealing with a particular area of study in the field of architecture and art history. The course will consist of four different exercises and tasks, carried out under the supervision of each of the four Chairs throughout the year:

1. Architecture and books (M. Delbeke)
2. Architecture and media (L. Stalder)
3. Architecture and art (P. Ursprung)
4. Urbanism and the Commons (T. Avermaete)

Literature

Course scripts, PowerPoint and lecture recordings for ‘History and Theory of Architecture I-II’ will be available to download from the course page at the beginning of the semester. Printed copies of the course scripts will also be available for purchase.

Prerequisites / notice

For the course ‘History and Theory of Architecture I-II’ students will rely on assisted self-study to acquire basic knowledge of the history of architecture in Europe.

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<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>052-0601-00L</td>
<td>Building Materials I</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>J. Pauli</td>
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</tbody>
</table>

Abstract

Building Materials - Introduction to the most common building materials

Objective

The lecture develops an understanding of different building materials and its application for construction under the aspects of material properties and ecological aspects.

Content

The lecture introduces the most common building materials concrete, steel, masonry and timber, but also clay, glass and polymers in a historical context. The fabrication processes are described and the most important properties regarding construction explained. A special focus is on the ecological aspects such as availability of raw materials, effort for production, emission of hazardous substances, disposal and recycling.

Lecture notes

Lecture slides as pdf

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<tr>
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<tbody>
<tr>
<td>052-0701-00L</td>
<td>Urban Design I</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>M. Wagner</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 72 of 2345
Abstract
The means and potentials in the field of urban planning and design are pointed out from different perspectives in order to shape the city in the sense of a future-proof and humane environment. To this end, the basic principles are explained and concrete methods of urban design are presented.

Objective
The goal is to provide students with a broad systemic basic knowledge, that enables them to synthesize and evaluate complex urban design and planning problems.

Content
The lecture series imparts basic knowledge in urban planning and design. Pressing questions and main topics of contemporary urban design practice and theory will be addressed. The focus is on illustrating the richness of relationships as well as the potential of the discipline and its handling in everyday urban planning and design practice.

Lecture notes
There is no script to the lecture series. The lectures are recorded on video and made available online on http://www.video.ethz.ch/lectures.html a few days after each lecture.

Literature
At the end of the year course a reader with secondary literature will be made available for download.

Prerequisites / notice
Further Information: https://www.staedtebau.arch.ethz.ch

052-0605-00L Computational Design I O 2 credits 2V B. Dillenburger

Title of this course before HS22: "Mathematical Thinking and Programming I"

Abstract
This course introduces computational design and teaches how design can be modeled and materialized using digital technology. Participants learn to use the computer strategically, thoughtfully, and sensitively within the design process. With the "digital literacy" acquired in this course, will develop an understanding of the potential of a digital building culture.

Objective
To systematically harvest the potential of the computer in their work processes, architects need an insight into the fundamental principles of information technology. In this course, students learn the concepts, methods, and instruments of computational design. By the end of the two semesters, students will have mastered the basics of 3D modeling techniques, parametric design, programming code for Computer-aided-design (CAD), and digital prototyping. The acquired knowledge qualifies students to use the computer as a unique instrument to model their designs. Participants also learn to apply CAD and programming code creatively and productively in planning, design, and construction.

Specifically, the learning goals are:
- Critical understanding of the possibilities of information technology in design
- Acquiring an overview of the mechanisms and types of CAD systems and digital building models
- Gaining knowledge of the basic principles of computational geometry
- Applying visualization techniques and creatively using various digital media
- Learning concepts and application of parametric design.
- Being able to integrate computer-aided analysis and optimization methods in design-process
- Understanding the principles of digital process chains from design to production
- Strategically using visual programming code
- Reading, understanding, and adapting programming code within CAD software.

Content
Architecture is no longer conceivable without information technology. The planning, construction, operation, and ultimately the nature of buildings are increasingly influenced by digital technology. The digital is omnipresent both in the work of architects and in our built environment itself.

The courses Computational Design 1 and 2 offer an introduction to the character, challenges, and possibilities of digital technology in architectural design. The lectures will discuss the topics of digital building models and data, computational geometry, digital fabrication, machine intelligence, and mixed reality.

In this course, students will practice digital modeling processes and related techniques. The spectrum of exercises includes manual modeling, visual programming, and programming code within CAD software. Students learn to read, understand and adapt this code. In addition, the courses will provide insights into the nature and handling of different digital media formats, from real-time rendering to mixed reality.

Topics discussed within the lectures:
- CAD - background, and developments
- On the nature of digital models and data
- Architectural geometry
- Computational geometry
- Parametric and generative creation of models
- Computer-aided analysis and optimization of models
- Artificial intelligence and architectural models
- Materialization of digital models
- Mixed reality

Course Structure
The course consists of theoretical lectures, practical tutorials introducing technical concepts, and exercises supported by tutors. Participants can find updated and detailed information on Moodle, which is the learning platform for the course.

Subjects with Semester Grade

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>052-0501-00L</td>
<td>Design and Construction I</td>
<td>O</td>
<td>8</td>
<td>4V+10G+2U</td>
<td>A. Deplazes, D. Mettler, D. Studer</td>
</tr>
</tbody>
</table>

Abstract
Designing and constructing will be understood to be a complementarily complementary offer. The content and methodical foundations of design and construction are taught and deepened through lectures and exercises.

Objective
Understanding and dominating the methodology of designing and constructing.

Content
Lectures and exercises to achieve the methodology and ability of designing and constructing.

Lecture notes
After a review of essential facts from the first year the course will examine the interplay of architectural concept and structural system by analyzing buildings of exemplary quality. The focus will be on the integration of specifics of structural systems made out reinforced concrete or steel into architectural design.

**Prerequisites / notice**

100% of interest and engagement!

Further Literature will be published in the lectures.

**Examination Blocks**

**Examination Block 1**

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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<tr>
<td>052-0503-00L</td>
<td>Architecture and Arts I</td>
<td>O</td>
<td>2 credits</td>
<td>2V+6G+1U</td>
<td>K. Sander</td>
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<tr>
<td></td>
<td><em>Project grading at semester end is based on the list of enrolments on 1.11.22 (valuation date) only.</em> This is the ultimate deadline to unsubscribe or enroll for the studio.</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Attendance in the lecture „Thinking and Speaking about Art“. Participation in three praxis-modules. Elaboration of three according artistic exercises in the framework of the group mentorates. (Emphasis of grading for the final semester grade: 3 x 1/3 artistic exercise.)</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>In the HS22, students prove artistic thinking and practise and develop their knowledge in three mentored praxis-modules with three independent artistic exercises.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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</thead>
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<tr>
<td>052-0607-00L</td>
<td>Structural Design III</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>J. Schwartz, P. Block</td>
</tr>
<tr>
<td></td>
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<td><strong>Objective</strong></td>
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<td><strong>Content</strong></td>
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<tbody>
<tr>
<td>052-0805-00L</td>
<td>History and Theory of Architecture III</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>L. Stalder</td>
</tr>
<tr>
<td></td>
<td><em>To introduce students to the history and theory of architecture, the course has three objectives.</em></td>
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<td><strong>Abstract</strong></td>
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<td>This two-semester course is an introduction to the history of architecture from the Second Industrial Revolution in the 1850s to the Oil Crisis in the 1970s in Europe. Students will be able to identify the &quot;things&quot;—technical objects and ensembles—that transformed architecture, and to relate them to the technical, scientific, and cultural concerns that introduced them as key features of modernity.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>First, students will be able to identify the &quot;things&quot; that transformed architecture in modernity, and the crucial events, buildings, theories, and actors that characterize their history.</td>
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<td>Second, students will be able to describe how these &quot;things&quot; operated at different scales, focusing less on the formal level, and naming instead the different forms of expertise that constituted them historically, as well as the processes within which they were embedded.</td>
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<td>Third, students will be able to reflect on a series of apparatuses, devices, and building parts that are in fact micro-architectures which have often been neglected, despite their pivotal role in shaping the daily lives of modern societies.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td>The course proposes a new approach to the study of the history and theory of architecture in Europe during modernity. It focuses less on single architects or their buildings, and more on those &quot;things&quot; that have brought profound transformations in the built environment and daily life over the last 200 years, such as the revolving door, the clock, and the curtain.</td>
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<td>The notion of &quot;thing&quot; includes both the concrete building parts and the concerns associated with them, such as material performance, social synchronization, and individual expression. To understand buildings as assemblages of &quot;things,&quot; therefore, does not mean to diminish their significance, but on the contrary to add reality to them, to understand them in terms of the complex, historically situated, and diverse concerns within which they were designed.</td>
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<td>Each lecture introduces one &quot;thing&quot; through a genealogy that shaped it, from patents and scientific discoveries and technological advancement, to cinema, the visual arts, and literature. A set of renowned projects as well as lesser-known buildings from all around Europe offers a variety of case studies to describe these &quot;things,&quot; to understand how they operated in relation with one another, and to identify the theories and tactics that architects mobilized to make sense of them.</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<tr>
<td></td>
<td><a href="http://www.stalder.arch.ethz.ch/courses">http://www.stalder.arch.ethz.ch/courses</a></td>
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</tbody>
</table>
Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

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

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

052-0635-00L Computational Design III
Title of this course before HS22: “Mathematical Thinking and Programming III”.
The lecture is held in German, the exercise n English Language.

Abstract
This class builds on the digital literacy foundations taught in the previous year and expands the acquired competence in the use of computers in design. At the core stands the question of how to use digital architectural design methods in a creative, purposeful and self-confident manner.

Objective
The course consists of lectures and exercises. The lectures convey an insight into strategies for the implementation of algorithmic techniques in architectural design by presenting and discussing the research and the build work of the professorship. This pragmatic view on the computational design process helps demystifying algorithmic techniques and developing a critical understanding for their potentials in the architectural praxis. Programming is an extension of traditional design tools. While this powerful cultural technique allows us to handle complexity in a previously unknown way, the question of its meaning, relevance and potential needs to be negotiated on a context specific base for every single project. In order to be able to do this, we shall develop a conceptual understanding for the methods as well as familiarity with the practice of programming. While the works discussed in the lectures sharpen the conceptual understanding, the tutored exercises will train the programming practice. In these sessions, we will implement simplified yet powerful versions of the discussed projects by using Rhinoceros 3D as a modeler and Grasshopper as a visual programming interface, both environments that have been introduced in the previous semesters. Up-to-date and detailed information on the lectures and exercises is announced on MOODLE, which will serve as the teaching platform for this course.

The specific learning goals are:
- To develop a critical awareness for the potentials of algorithmic design methods.
- Learn to deploy parametric design strategies.
- Become familiar with the practice of visual programming.
- Understand the concepts and potentials of digital fabrication.

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-8009-00L</td>
<td>Building Physics II</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>J. Carmeliet, M. Ettlin, A. Rubin</td>
</tr>
</tbody>
</table>

Abstract
Moisture related problems are common in buildings leading to costly damage and uncomfortable indoor environments. This course aims at providing the necessary theoretical background and training in order to foresee and avoid these problems.

Objective
- to develop a basic understanding of mass transport and buffering to become aware of potential moisture-related damage and health risks
- to learn how to (i) design building components and (ii) assess their hygrothermal performance
- • hygrothermal loads
- • conservation of mass (dry air, water vapor, liquid water)
- • moist air: constitutive behavior, transport, potential problems and solutions
- • liquid water: constitutive behavior, transport, potential problems and solutions
- • exercises

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Prerequisites / notice
Prior knowledge of “BP I: heat” is required.

052-0801-00L Global History of Urban Design I

Abstract
This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

Objective
The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.
In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01: The History and Theory of the City as Project
02: Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03: The Idea of the Polis: Rome, Greece and Beyond
04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
09: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
10: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
11: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuiderplein

Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

Literature

There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

Prerequisites / notice

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

Lecture notes

The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings

Content

Urban Design III

Students are introduced to a narrative of ‘Urban Stories’ through a series of three tools driven by social, governance, and environmental transformations in today’s urbanization processes. Each lecture explores one city’s spatial and organizational ingenuity born out of a particular place’s realities, allowing students to transfer these inventions into a catalog of conceptual tools.

Objective

How can students of architecture become active agents of change? What does it take to go beyond a building’s scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how.

We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

Number

Title

Type
ECTS
Hours
Lecturers

052-0807-00L

History and Theory of Architecture V

History of Art and Architecture since the 1970s

Type
ECTS
Hours
P. Ursprung

Data: 18.08.2022 12:39
Autumn Semester 2022
Page 76 of 2345
Content
The two-semester course offers an introduction to the history of modern and contemporary art and architecture since ca. 1970. Motivated by questions of the current discourse, central topics and exemplary works of art and architecture are discussed. Concepts such as “labor”, “economy”, “experience”, “research”, “nature”, “diversity” or “surface” are used to focus on specific historical developments and connections. Art and architecture is considered as a field of cultural change as well as an indicator of social, economic, and political conflicts which in turn helps to understand historical dynamics.

Lecture notes
A video documentation of the lecture class is available. https://video.ethz.ch/lectures/d-arch/2019/052-0807-00L.html

Literature
Philip Ursprung, Der Wert der Oberfläche, Essays zu Kunst, Architektur und Ökonomie, Zürich, gta Verlag, 2017.

052-0651-00L  Building Process I  O  2 credits  2G  S. Menz
Abstract
The building process is the main focus of this lecture series. The process is understood as a sequence of criteria in time. Topics: Acquisition and building law, building economics and sustainability strategies, participants and their services, construction and planning organization.
Process thinking and a look at neighboring countries complement the series.

Objective
Alongside a discussion of the basic principles, trends and terminologies, a closer look will be taken at each topic using case studies that investigate current structures as well as those relevant in terms of architecture and urban design. Active participation as well as interdisciplinary and process-oriented thinking on the part of students is a prerequisite.

Content
The building process is the main focus of this lecture series. The process is understood as a sequence of criteria in time. Topics: Acquisition and building law, building economics and sustainability strategies, participants and their services, construction and planning organization.
Process thinking and a look at neighboring countries complement the series.
Alongside a discussion of the basic principles, trends and terminologies, a closer look will be taken at each topic using case studies that investigate current structures as well as those relevant in terms of architecture and urban design. Active participation as well as interdisciplinary and process-oriented thinking on the part of students is a prerequisite.

Lecture notes
A video documentation of the lecture class is available. https://video.ethz.ch/lectures/d-arch/2019/052-0807-00L.html

052-0705-00L  Landscape Architecture I  O  2 credits  2V  C. Girot
Abstract
Introduction to the history and theory of garden design and landscape architecture. Analysis of the design of historical gardens and landscapes within the cultural background.

Objective
The course covers the basic history and theory of garden design and landscape architecture from its beginnings to the 21st century. The course aims to raise awareness of a changing perception of nature and landscape.

Content
The lecture series on History and Theory of Garden Design and Landscape Architecture deals with the historical development of designed nature, from the beginnings of cultural landscapes and gardens to 21st century landscape architecture. In the analysis of each era, the focus is on the spatial and cultural relationship between the garden, the city and the landscape, as well as the changing perceptions of nature and its representation.

Lecture notes
Handouts and a reading list will be provided.

Literature
A reading list will be provided for the exams.

Prerequisites / notice
General Information for the final exam:
Backlog of students: The content of the lectures as well as texts and exam-relevant literature provided by the Chair make up the basis for preparing for the exam. The lecture series is conceived as a yearlong course. Since the written session examination will test knowledge from both semesters, it is necessary to fully attend the lectures of both courses “Landscape Architecture I” and “Landscape Architecture II”. The themes of the examination will be announced at the end of the semester. The Chair will provide literature and texts available for download as pdfs. These allow a more in-depth understanding of the lecture material.

Exchange students or students from other departments: Students, who are attending only one semester, may pass the oral end-of-semester examination. Test-relevant literature will also be made available for download for this purpose. The students are requested to get in touch by email with the Chair.

052-0609-00L  Energy and Climate Design I  O  2 credits  2G  A. Schüler
Abstract
This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

Objective
At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=11917). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

Content
Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:
1. Local potentials
2. Demand estimation
3. Supply concepts

Lecture notes
Material on moodle serves as lecture notes.

Literature
A list of relevant literature is available at the chair and through moodle.

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

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Sensitivity to Diversity
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-direction and Self-management

052-0507-00L  Architectural Technology V  O  2 credits  2V  C. Kerez
Abstract
Construction is the prerequisite for making an architectural, spatial idea tangible in the first place. In this lecture series, it is understood as a component of a holistic, coherent architecture and is derived from its architectural, spatial context on the basis of a broad selection of buildings.

Objective
The lecture series does not provide instructions or recipes on general constructive topics. The description of distinctive, spatial experiences and the constructive measures used to achieve them, is rather intended to sharpen the students' awareness, for their own design work and to show countless possibilities of how an architectural, spatial idea can be understood and further developed through its material, its construction method and its supporting structure.

Content
The buildings, which are described and explained in the lectures, differ fundamentally from each other in their time of origin, their urban context, as well as their geographical location and could hardly be more different in their scale and their use. These buildings are not a typical expression of their time and location, instead they are an expression of an individual creation and likewise use the constructive possibilities of their time and their environment in a distinctive way. Accordingly, each lecture is dedicated to a different architect.

In addition, isolated current examples from professional practice will be shown. These lectures on new buildings, some of them unfinished, are given by an architect directly involved on site, in English, and partly online.

Lecture notes
The script is a comprehensive collection of material that allows students to form their own ideas about the case studies shown, independent of the lecture. Most of the photographs were taken on study trips and show the buildings under discussion with unpublished material. The extensive collection of photographs is supplemented with drawings, plans, site photographs, and historical photographs from books and archives. The script will be made available in digital form at the end of the semester to students enrolled in the lecture series.

Literature
The script will be made available in digital form at the end of the semester to students enrolled in the lecture series.

Prerequisites / notice
Structure and topics of the lecture series:
26.09.22: Einleitung
03.10.22: John Lautner
10.10.22: Kazuo Shinohara
17.10.22: Francesco Borromini
31.10.22: Louis Kahn
07.11.22: André Block
14.11.22: 4 Parkings Bahrain
21.11.22: Pavillon-Expo 2020 Dubai
28.11.22: Folgt
05.12.22: Folgt

The examinations test knowledge of the buildings presented in the course of two semesters. The focus of the exam, as well as the lecture, is the understanding of the indissoluble connection between the spatial experience or conception of a building and its construction, its load-bearing structure, its construction process and its materials.

The lectures are not a mandatory prerequisite to pass the exam, but a clear introduction to the exam material, as well as a facilitation to understand and deepen the exam material. The structure of the exam material changes from one semester to another and from one year to the next. Exams can therefore only cover the lectures of a whole year.

Mobility students or students from other departments who only want to take the exam on the material from the last semester (Construction V or VI) are asked to contact the chair in advance.

Architectural Design

Architectural Design (3. Semester)

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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</table>

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Students who do not wish to change the design class don't have to participate in the internal enrolment.

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only.

This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
To follow

Objective
To follow

Content
To follow

Literature
Book recommendation BUK I - IV: “Construction”;
A reference work on contemporary construction
German or English
360 pages, 171 images, 20 color images, texts
ISBN 978-3-0356-2225-6
Online reference source: https://www.hochparterre-buecher.ch/ Konstruktionen.html

Prerequisites / notice
To follow
Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Sensitivity to Diversity: assessed

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

052-0543-22L Architectural Design III: Topic (Kajjima)

Project grading at semester end is based on the list of enrolments on 1.11.22 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
To follow

Objective
To follow

Content
To follow

Lecture notes
To follow

Literature
- Atelier Bow-Wow, Behaviorology, Rizzoli International Publications, New York, 2010

Prerequisites / notice
To attend this course, students have to enroll through the “Enrolment in the Design Studios of D-ARCH”-page: (www.einschreibung.arch.ethz.ch/).
The design studio is structured as a year-long course.
The submissions during the autumn semester will be individual work.

052-0545-22L Architectural Topic (R. Boltshauser)

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is also the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
To follow

Objective
To follow

Content
To follow

Lecture notes
To follow

Literature
- Atelier Bow-Wow, Behaviorology, Rizzoli International Publications, New York, 2010

Prerequisites / notice
To attend this course, students have to enroll through the “Enrolment in the Design Studios of D-ARCH”-page: (www.einschreibung.arch.ethz.ch/).
The design studio is structured as a year-long course.
The submissions during the autumn semester will be individual work.

052-0547-22L Architectural Design III: Topic (J. De Vylder)

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is also the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
To follow

Objective
To follow

Content
To follow

Lecture notes
To follow

Literature
- Atelier Bow-Wow, Behaviorology, Rizzoli International Publications, New York, 2010

Prerequisites / notice
To attend this course, students have to enroll through the “Enrolment in the Design Studios of D-ARCH”-page: (www.einschreibung.arch.ethz.ch/).
The design studio is structured as a year-long course.
The submissions during the autumn semester will be individual work.
internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). Students who do not wish to change the design class must not enrol.

Project grading at semester end is based on the list of enrolments on 1.11.22 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

To follow

Objective

To follow

Content

To follow

Prerequisites / notice

To follow

Taught competencies

Subject-specific Competencies

Concepts and Theories

assessed

Method-specific Competencies

Project Management

assessed

Social Competencies

Cooperation and Teamwork

assessed

Sensitivity to Diversity

assessed

Negotiation

assessed

Personal Competencies

Adaptability and Flexibility

assessed

Creative Thinking

assessed

Critical Thinking

assessed

Integrity and Work Ethics

assessed

Self-awareness and Self-reflection

assessed

Self-direction and Self-management

assessed

Architectural Design (from 5. Semester on)

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

To follow

Objective

To follow

Content

To follow

Prerequisites / notice

To follow

052-1101-22L Architectural Design V-IX: Topic (A. Caminada)  

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

To follow

Objective

To follow

Content

To follow

Lecture notes

To follow

Prerequisites / notice

To follow

No extra costs,

052-1105-22L Architectural Design V-IX: Topic (J. De Vylder)  

Does not take place this semester.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

To follow

Objective

To follow

Content

To follow

Prerequisites / notice

To follow

052-1109-22L Architectural Design V-IX: Topic (L. Hovestadt)  

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Abstract

To follow

Objective

To follow

Content

To follow

Prerequisites / notice

To follow

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 80 of 2345
## 052-1113-22L
### Architectural Design V-IX: Topic (A. Theriot)
- **W** 14 credits 16U  A. Theriot

<table>
<thead>
<tr>
<th>Taught competencies</th>
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## 052-1115-22L
### Architectural Design V-IX: Topic (T. Emerson)
- **W** 14 credits 16U  B. Gusic, T. Emerson

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## 052-1117-22L
### Architectural Design V-IX: Topic (A. Gigon)
- **W** 14 credits 16U  A. Gigon

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## 052-1119-22L
### Architectural Design V-IX: Topic (A. Brandlhuber)
- **W** 14 credits 16U  A. Brandlhuber

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Objective  To follow  
Content  To follow  
Prerequisites / notice  To follow

**052-1121-22L**  Architectural Design V-IX: Topic (F. Persyn)  
Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Abstract  To follow.
Objective  To follow  
Content  To follow  
Prerequisites / notice  To follow

**052-1123-22L**  Architectural Design V-IX:  
Does not take place this semester.

Abstract  To follow.
Objective  To follow  
Content  To follow  
Prerequisites / notice  To follow

**052-1125-22L**  Architectural Design V-IX: Topic (E. Mosayebi)  
Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Abstract  To follow.
Objective  To follow  
Content  To follow  
Prerequisites / notice  To follow

**052-1127-22L**  Architectural Design V-IX: Designing Flood Relief Landscapes in Antananarivo (Girot)  
Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Abstract  To follow.
Objective  To follow  
Content  To follow  
Prerequisites / notice  To follow

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W  14 credits  16U  F. Persyn
W  14 credits  16U  E. Mosayebi
W  14 credits  16U  C. Girot

Taught competencies

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

- Method-specific Competencies
  - Analytical Competencies  assessed
  - Decision-making  assessed
  - Media and Digital Technologies  assessed
  - Problem-solving  assessed
  - Project Management  assessed

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

- Personal Competencies
  - Adaptability and Flexibility  assessed
  - Creative Thinking  assessed
  - Critical Thinking  assessed
  - Integrity and Work Ethics  not assessed
  - Self-awareness and Self-reflection  assessed
  - Self-direction and Self-management  assessed
The Landscape Architecture Studio in the Fall 2022 will investigate the innovative designs for flood relief in Antananarivo. It will address the peri-urban context of the city that is subject to severe seasonal flooding. The site-specific approach includes modeling of resilient landscape infrastructures to enhance the safety of neighborhoods located on the banks of the Ikopa and Sisaony rivers.

Objective

The goal of this Design Research Studio is to develop design solutions for the flood prone areas of Greater Antananarivo, Madagascar, implementing a resilient landscape infrastructure. Students will learn digital modelling techniques through topological analysis and design. This will enable them to imagine and design precise flood- and food-resilient landscape systems in the urban-agricultural context of Antananarivo. The digital models will be assessed for their performance and feasibility through pluvial simulation models and ecosystem services assessment. Through the use of precise modeling techniques based on laser-scanned data, students will learn to move iteratively towards a final landscape design proposal that will compound topography, infrastructure and vegetation. The studio is part of an ETH Future Cities Laboratory collaboration with researchers and designers from local universities, that will strengthen our knowledge about the broader socio-ecological context of Madagascar. The studio includes a compulsory site visit to Antananarivo for ETH students in the Autumn of 2022.

Content

Designing resilient landscapes in flood prone areas of Antananarivo, Madagascar

The capital city of Madagascar, Antananarivo, is a high-altitude city. Urban growth is changing rapidly the traditional landscape of the Merina culture dominated by rice cultivation in the plains, as informal settlements are more and more occupying the rice plain. This uncontrolled growth also increases the demand for local bricks produced from soil mining, degrading the existing agriculture. In addition, there are back-fills that eat away at the capacity of the city to cope with flooding. As a result, the infrastructures coping with floods in the city are no longer adequate. Many canals originally built by rulers for irrigation purposes are now embedded in the urban fabric and have been subverted into open air sewers. The proximity of rice fields with the informal settlements creates added difficulty for farmers to organize irrigation or to cope with city’s effluents on crops. Madagascar is one of the poorest countries in the world. These challenges bring an opportunity to construct a resilient and more sustainable landscape environment for the city, capable of integrating urban growth with measured flood management and sustainable food production.

The studio will propose a series of new designs for an agro-urban flood-food landscape adapted to the present situation. The intention would be to develop designs that integrate flood and irrigation management while keeping key benefits that city dwellers get from their local ecosystem. This will be achieved through the enhanced capabilities of 3D point cloud modelling and design. The design of significant landscape changes in Antananarivo draws from a combination of design and analysis methods to find adaptive solutions. These design tools supported by scientific feedback will initiate an iterative process between capturing, analyzing and visualizing possible futures. The designed landscape scenarios developed by the students will be assessed in their performance and feasibility according to pluvial model simulation and the ecosystem services they provide. New landscape designs will be integrated to flood- and food-resilient scenarios urgently sought by Malagasy society. The studio philosophy is to build on the strengths of the current socio-ecological interactions that exist locally. The studio will aim at bridging design, engineering and science, by promoting novel ways to transform urban landscapes in the context of Antananarivo, providing more resilient habitat for citizens living under severe climate and socio-economic changes with a particular focus on local food production.

Literature

Booklet and reader will be delivered at the beginning of classes.

Prerequisites / notice

Work in teams of 2 is advised.

Integrated (obligatory) seminar week to Antananarivo (24.-28.10.22)
(Kosten: ca. CHF 500.--)
Number of participants will be limited to 18 students.

The studio will include "Integrierte Disziplin Planung" (063-1402-13), 3 ETCS credits


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Abstract

To follow

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To follow

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| **052-1137-22L** | Architectural Design V-IX: Topic (M. Conen) |
| W | 14 credits | 16U | M. Conen |
| Does not take place this semester. Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). |
| Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio. |
| Abstract | To follow |
| Objective | To follow |
| Content | To follow |
| Prerequisites / notice | To follow |

| **052-1139-22L** | Architectural Design V-IX: Circular City (H. Klumpner) |
| W | 14 credits | 16U | H. Klumpner |
| Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). |
| Teaching Languages: English and German |
| Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio. |
| Abstract | Let’s build a circular city, transiting towards a zero-waste community. The promise of unlimited growth perpetuates our culture of unsustainable material flows and the production of junk products. Could we value resources, act socio-ecological responsive, and design a Circuit-Workshop prototype into a system of productive public spaces, as commons for work and community? |
| Objective | Students immersed in our “method-design”, will develop a system of individual prototypical design projects. We moderate and guide a trans-scalar understanding of architecture, urban design, and planning, developing collaboratively a baseline scenario. Research by mapping, identifying, reading context, existing and future challenges and opportunities, assist students taking on roles of decision-making stakeholders, to Co-creative translate their findings and resources into different scenarios. We synthesize the scenarios in design strategies and urbanistic concepts, translating them into an evidence-based, prototypical architectural project intervention. This prototype responds to dynamic real-world processes, over time and space. We frame urban design projects as a narrative, that is consequently visualized and communicated in analog and digital graphic and model representations. The concept project will be tested and upscaled through urbanistic design-policy recommendations within overlapping spatial and programmatic systems and material propositions into an architectural relevant pilot project. Based on our Chair’s “Urban Stories” lecture series, students will use the reference framework of the urban toolbox and our catalog of evidence-based design examples of what works and what are the trade-offs in the complexities of a specific environment. Design solutions are responding to the site’s environmental, social, and governance challenges and context. At the intersection of urban- and landscape design, and public arts, we envision trans-scalar dynamic developments and radical urban imaginaries for societal transformation. “(...) we believe that we have enough buildings, enough construction, enough infrastructure. And it is now time to consolidate it and find the qualities within the built. This is not against future production, it is more about a consideration of what we really want in cities.” (AD Interviews: Hubert Klumpner / 2015 Bi-City Biennale of Urbanism/Architecture) |
| Content | We will discuss spatial processes following our practical, real-life experiences, consolidating along a sequence of transformative steps of short-term tactics for long-term strategies and value production. We will scrutinize the need to re-evaluate neighborhoods’ transformations initiated by art, popular culture, local participation, densifying social interaction, and place-making with our concern to avoid displacing existing populations. Urban- and Landscape Design can create a measurable positive impact in cities by caring for social justice, health, and wellbeing in times of climate change. The development of a robust framework enables regeneration processes with long-term operational, environmental and social benefits in response to global, local, and site-specific challenges. The role of architects is to imagine and model sustainable urban scenarios recognizing urban corridors as new possibilities and lifelines to impact meaningful and multidimensional transformative design strategies. For every city, design is about different things; what remains are the values, choices, opportunities, and engaged societies and how we realize and implement a concrete project in a city neighborhood relevant to our care for earth. |
| To follow | | |
"Method-design": Systematically engaging students in the Studio topic, to unlock their potential and skills towards developing prototypical design resolution on an urban and architectural scale. Identifying, understanding and developing local stakeholder networks, so as to translate challenges into opportunities and negotiate diverse interests into strategic ideas for development, geo-references, inter-linked systems, diagrams and maps. Develop design concepts for urban prototypes on different scales, framed by a narrative of a process that is consequentially visualized and communicated in analog as well as digital tools.

Investigative Analysis/ Local Perspective: Registering the existing; prioritizing challenges and opportunities through qualitative and quantitative information; mapping on different design scales and periods of time; configuring stakeholder groups; connecting top-down and bottom-up initiatives; idea mapping and concept mapping; designing of citizen scenarios.

"Project Design": Synthesizing between different scenarios and definition of a thesis and program between beneficiaries and stakeholders; projecting process presentation as a narrative embedded in multiple steps; describing an urban and architectural typology and prototypes; defining an urban paradigm.

"Domain Shift": Shifting and translating different domains; testing and evaluating the design in feedback loops; including the project in the dynamic context of the neighborhood, testing the potentials for upscaling and policy relevance as part of the reference framework of the Chairs Urban Toolbox.

The studio reader can be downloaded from the server. Reading material, reference texts and case studies are available throughout the semester.

Titles include: SDG 11 by Klumpner, Papanicolaou, Ulrich Beck, Yona Friedman, Donna Haraway, Victor Papanek, Richard Sennet, and other critical texts cultivating plurality, social-culturally engaged approaches, and expand the field of architecture.

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Titles include: SDG 11 by Klumpner, Papanicolaou, Ulrich Beck, Yona Friedman, Donna Haraway, Victor Papanek, Richard Sennet, and other critical texts cultivating plurality, social-culturally engaged approaches, and expand the field of architecture.
Abstract

The alpine landscape is changing at an accelerated pace. This development is contrasted by a rudimentary description of the space as a basis for current planning. Against this background, we argue for a comprehensive and fine-grained profiling of the Alps as a starting point for the design of new landscapes. This under the premise of creating maximum difference.

Objective

Independent thinking and acting

Content

Increased pressure on the alpine landscape

The alpine landscape is changing at an accelerated pace. Progressive urbanization as well as climate change are fundamentally transforming the sensitive structure. In the course of this development, the importance of the Alps will strongly increase with regard to a broader context, because the manifold existing resources (fresh air, water, biodiversity) arouse numerous desires. The conflicts of interest and use that already exist today are likely to become even more acute as a result.

Blurred view

The development contrasts with a rudimentary description of the Alpine region as a basis for current planning. The picture here is characterized by the notion of a heterotrophic division of space (urbanity vs. wasteland). A consequence of this is the paradoxical situation that concrete projects are negotiated on a case-by-case basis and corresponding (and urgently needed) developments stagnate (cf. the discussion about new hydroelectric power plants).

Rethinking the Alpine Space

Against this background, we plead for the most fine-grained and multi-layered coverage of the space as a starting point for further discussion. This approach is based on the insight that the characteristic feature of the alpine landscape has always been its pronounced small-scale character, whereby each valley community is characterized by specific peculiarities, primarily due to the landscape conditions. We want to trace this "substrate of the landscape" and place it at the beginning of further considerations. In doing so, we are concerned with the accelerated generation of difference. For in the Alpine region "the other" is omnipresent in the neighborhood and has both an identity-forming and a stabilizing effect on the existence of the diverse communities.

Profiling landscapes

During the semester we will look at alpine valleys on the basis of a concrete case. From this intensive reading of space, we derive specific uses for each spatial chamber, which will subsequently be further sharpened and visualized using design tools. The image of future alpine landscapes has a double meaning. It bundles the levels of use and perception into a synthesis, but it is also the iconographic version of that vision which is to seduce a community into communal action in space. The attempt to find a centered image, a theme for the identification of a place, acts as a speculative anticipation on the way to profiling the Alps. At the same time, the image is always to be understood more as an analysis than as a design, insofar as it represents a theoretical version and evaluation of the already existing lines of development.
052-1107-22L Architectural Design V-IX: Topic (Guest Prof. M. Voser.)

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
Amplitude. Dynamic landscape structures for the Zeeland.

Objective
The search for future-oriented strategies in dealing with these extremes requires a paradigm shift - from fighting against to working with natural processes. It is necessary to lay new landscape structures that can deal with the fluctuations of the amplitudes.

Content
Heat, drought, heavy rain events - in the course of climate change, the extremes are getting stronger and the frequencies in which they occur faster and faster. Natural and cultural landscapes that were in equilibrium until a few years ago need to be adapted. These changes will not only affect the life of flora, fauna and people, but also the character and ultimately the identity of our Swiss landscape.

The search for future-oriented strategies in dealing with these extremes requires a paradigm shift - from fighting against to working with natural processes. It is necessary to lay new landscape structures that can deal with the fluctuations of the amplitudes.

But how can the forces of extremes be used and turned into positive things? And how should the new landscape deal with the dynamics - direct, balance, absorb?

As the most important production area in Switzerland, the Three Lakes Region is exposed to these extremes, as witnessed by the debris flow in Cressier and the floods in July as well as the dry periods of recent years. Therefore, the third Jura water correction is currently being considered, which, in addition to the previous tasks of large-scale drainage and bed load management, also includes irrigation.

The territory between Lake Neuchâtel and Lake Biel is characterized by the most varied levels of culture, infrastructure, settlement and industrial landscapes. The spatial planning consideration reveals extremes: small-grained, historical settlement cores collide with sprawling industrial areas such as the last refinery in Switzerland.

In search of new scenic identities for this valley, we will deal intensively with systems, processes and strategies without losing sight of spatial qualities, atmospheres and poetry.

The introduction of a new water system serves as a design engine. Due to the complexity of the territory and the task, an iterative design method is pursued that oscillates between design and analysis and between large and small scales. The development of an attitude, the crystallization of the specific topics and the selection of the appropriate design means are just as much a part of the work process as the design of the transformation processes.

052-1201-22L Preparation Semester Free Master Thesis HS22

Objective
Self-dependent development of a program, according to which one intends to realize a free master thesis in the following semester.

052-1149-22L Architectural Design V-IX: Immersive Studio

(Gramazio/Kohler)

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
We are used to designing architecture from a supposedly objective perspective. With immersive technologies, we overcome our distance, expand our perception and give directly into the space to be designed. In doing so, we develop an altered understanding of space, design and representation of complex / dynamic systems and landscapes, alternation between different scales.

Objective
In the "Immersive Studio" we will get to know contemporary digital design methods and apply them in a creative, sensitive and meaningful way in our architectural designs. We will critically reflect the potentials of these technologies beyond a pure efficiency thinking and develop an independent, mature and emancipated attitude towards them.

We will achieve this by consistently developing our designs on the digital 3D model. We will generate and edit this both by manual modeling and, where useful and interesting, algorithmically and parametrically. We will regularly walk through the designs in virtual space, analyze them spatially and discuss them.

Despite the intensive and extensive use of digital methods, the architectural design, its materialization and fabrication as well as sustainability will be at the center of our investigation.

Electives and Focus Works

Design and Architecture

Electives

Planning Strategies for Complex Buildings Using the Example of Health Facilities

Abstract
Independently written scientific paper concerning a subject of planning of complex buildings - such as health facility planning and design - with special focus upon the dynamic changes in this context and the related planning and building reactions to them.

Objective
The objective is that the students engage in a debate of a differentiated functional planning as a basis for complex buildings which are to be successful functionally, operationally and in design.

On the basis of a given scope of themes the students carry out research aiming for possible improvements for example in health facility planning. The scope of subjects is announced at the beginning of each semester.
Complex buildings such as health care buildings are subject to constant change. In a new hospital building 60% of the diagnostic and treatment areas are subject to building changes within the first 10 years of operation. Architecture has to develop concepts which accommodate this level of dynamics into the building structure in a better way. In the coming years this need for adaptability is going to be challenges even further by the even more reducing health care resources. The paper should discuss in this context a specific question in detail by analysing problems and developing and discussing potential planning solutions.

The Chair of Architecture & Art at ETH Zurich, Department of Architecture thinks and realizes in basic research since 2012 in the topic of new media in architecture. The research journey went over person scans, high resolution 3D scans as certificates of authenticity for art rental to spatial Lidar scans in punk clouds. Since 2016, there is the possibility of VR technology. To experience virtual worlds with VR glasses. The knowledge from scan, texture and feedback from scan to CAD allows us to experiment with VR glasses. We from the research of the Department of Architecture and Art are looking at issues such as space and time, the dimensions and gravity in a metaVers, metavers, the synonym for virtual worlds. Further, we consider how the handling of VR glasses takes place in the consumer. How are the VR goggles used, donned or held in the different applications.

Please send us a letter of motivation as to what your aspirations, goals / desires are for this elective.
grueninger@arch.ethz.ch; kiryk@arch.ethz.ch

Tools where we use:
Gravity Sketch
Reality Capture (3D scan program)
Unity
TwinMotion
Oculus Quest 2
USB for Oculus Link (Beta Oculus Air)

These are the tools we will use and learn as we journey together "Designing in Virtual Space".

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USB for Oculus Link (Beta Oculus Air)

These are the tools we will use and learn as we journey together "Designing in Virtual Space".

The Chair of Architecture & Art at ETH Zurich, Department of Architecture thinks and realizes in basic research since 2012 in the topic of new media in architecture. The research journey went over person scans, high resolution 3D scans as certificates of authenticity for art rental to spatial Lidar scans in punk clouds. Since 2016, there is the possibility of VR technology. To experience virtual worlds with VR glasses. The knowledge from scan, texture and feedback from scan to CAD allows us to experiment with VR glasses. We from the research of the Department of Architecture and Art are looking at issues such as space and time, the dimensions and gravity in a metaVers, metavers, the synonym for virtual worlds. Further, we consider how the handling of VR glasses takes place in the consumer. How are the VR goggles used, donned or held in the different applications.

Please send us a letter of motivation as to what your aspirations, goals / desires are for this elective.
grueninger@arch.ethz.ch; kiryk@arch.ethz.ch

Tools where we use:
Gravity Sketch
Reality Capture (3D scan program)
Unity
TwinMotion
Oculus Quest 2
USB for Oculus Link (Beta Oculus Air)

These are the tools we will use and learn as we journey together "Designing in Virtual Space".
We focus on virtual reality design process and create our own spaces using VR-headsets. We hope that this new technologies will change the design of architecture in the near future and will influence the learning process at ETH as well.

The goal is to 3D-scan an existing space and use it in VR as a context for further design.

First, we learn the tools; then we work on an architectural VR-project; at the end of the course, we present the works in our exhibition space in HIL F.

Every Student gets Oculus Quest VR-Headset to work with at home during the semester.

Each student will be charged with 200 chf deposit for the VR-Headset 2 Weeks before the beginning of the course. The deposit has to be paid the latest 2 weeks before the beginning of the course. It will be paid back after the return of the Headset (it has to be returned until Monday, 19.12.2022).

In case of loss or damage that is uncovered by the warranty the student has to cover the equipment cost 510chf (minus 200chf deposit).

If you already have Oculus Quest (Model 1 or 2) you don’t need to pay any deposit and you can work on your own device.

Prerequisites / notice

Course requirements:
Both courses are connected “360 – Reality to Virtuality” and “3D-Modeling”
Please register for both courses: “360 – Reality to Virtuality” (052-0523-00L) and “3D-Modeling” (052-0521-00L) (2x 2 ECTS)
Classroom-teaching (online or physical meetings, Mondays, 14:00 – 16:00)
Self-teaching, research etc. (Mondays 12:00 – 14:00, or whenever you have time)

Please send us your short letter of motivation to Nicolas Rolle: rolle@arch.ethz.ch

Tools:
Gravity Sketch
Photogrammetry 3D-scanning (Reality Capture)
Oculus Quest 2
Oculus Link (USB-C cable)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>052-0535-22L</td>
<td>Model and Design</td>
<td>3</td>
<td>U</td>
<td>A. Tellini, C. Egli</td>
</tr>
<tr>
<td>052-0537-22L</td>
<td>Free Drawing</td>
<td>2</td>
<td>V</td>
<td>H. E. Franzen</td>
</tr>
<tr>
<td>052-0549-22L</td>
<td>Hybrid Modeling: 3D-Printing for the Architectural Design</td>
<td>2</td>
<td>S</td>
<td>J. Benhamu Esayag</td>
</tr>
</tbody>
</table>

Number of participants limited to 35.

The elective subject "New focal points of construction" investigates the complexe interaction of construction elements in masonry by means of exemplary architectonic tender points such as base, wall, chamber, roof etc.

The comparative analysis of built constructions serves as a basis for further development of future constructions.

Course:
1. Introduction of current level of technique, typical methods, and set of problems in masonry
2. Colloquium with guests of producing and processing companies.
3. Visit of construction site and factory

Excercise:
Analysis and presentation in group of two of a building.

https://www.buk.arch.ethz.ch/Lehre/NKOHS2022

Number of participants limited to 27

The HYTAC Elective Course offers the opportunity to explore alternative ways to approach Context Analysis. The students will learn the basic principles and workflows behind photogrammetry, 3d-modeling and 3D-printing, to produce digital and physical (3d-printed) models using drone footage.


Objective
By the end of this course, the students will be capable of:

a) flying a drone
b) creating and processing point-cloud-generated context models
c) producing 3D-printed site-models in architectural scale
d) using the above digital tools to advance their personal design workflows.
The goal of the course is to introduce digital technologies and facilitate common architectural workflows by skipping the time-consuming processes of 3D context modeling.

The course includes:
- Introduction to photogrammetry and 3D printing through lectures and tutorials.
- Flight-Days: students will get the possibility to fly a drone (DJI Mavic 2 Zoom) at the site of interest.
- Generation of a digital twin of the selected site through photogrammetry and production of a physical model (3D printed)
- Use of CAD software like Rhino, Blender and ArchiCAD. Basic skills can be acquired during the course.
- A small design challenge using the newly learned skills.

In case of questions regarding the course, please visit our website: https://hytac.arch.ethz.ch/courses/elective-2/ or contact us directly via email (hytac@arch.ethz.ch).

www.3djony.com

Basic Knowledge of 3D printing technology is required.

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<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>Semester</th>
<th>Lecturer(s)</th>
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<tbody>
<tr>
<td>052-0561-22L</td>
<td>Territories of Play - Mise-En-Scène</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>P. Heiz, F. Charbonnet, S. Hägele</td>
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<td></td>
<td><strong>Number of participants limited to 18</strong></td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The course stresses the scenographic aspect of game environments and their relation to architecture. Game sets --be it virtual or material-- will be explored in their spatial behaviour and their prosthetic impact on the player: as décor or field, loaded with rules, limits and opportunities. In „Junk Space“ Rem Koolhaas unmasked the current condition of architecture on a global scale: The contraction into a hollow surface that is in constant transformation, with an overwhelming emphasize on effects, light, sounds and odours. Atmosphere without material. Games go even further as their scenography is liberated from architectures biggest burden: substance and gravity. What spatial phenomena take place in the ever more present game environments? The course is echoing a fascinating genealogy that runs through the history of architecture itself: Dematerialisation, Scenography, Limits, Thresholds, Gib doors, Hidden rules, Trompe-l’œil, Illusions, Décor, Frescos, Marbleising, etc.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>The course will look into the backdrop qualities of various games and how they interact with the players. The course will be structured into three distinct and complementary moments: 1. Portraying of an existing game 2. Extrapolating of a specific feature of the game scenography. 3. Application on an real world situation. For more information, please write to: <a href="mailto:haegele@arch.ethz.ch">haegele@arch.ethz.ch</a></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>For more information, please write to: <a href="mailto:haegele@arch.ethz.ch">haegele@arch.ethz.ch</a></td>
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<td><strong>Taught competencies</strong></td>
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<td><strong>Subject-specific Competencies</strong></td>
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<td><strong>Personal Competencies</strong></td>
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<td>052-0569-22L</td>
<td>Lecture Series Design and Architecture: One Building - Failure Is an Option 3/4</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>P. Heiz</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Specialists give lectures on current architecture-specific topics.</td>
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<td><strong>Objective</strong></td>
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<td>Obtaining knowledge from architectural practice after 2020.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>Specialists give lectures on current architecture-specific topics.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Lecturers are listed in due time. The lecture series take place Tuesdays 18-20 Uhr (s. room reservations) 20.09.2022: Prof. Arno Brandhuber, HIL E4; 27.09.2022: Prof. Andrea Deplazes, HIL E4; 04.10.2022: Prof. Karin Sander, HIL E4; 01.11.2022: Prof. Emanuel Christ, HIL E4; 15.11.2022: Prof. An Fonteyne, ONA E7; 29.11.2022: Prof. Elli Mosayebi, HIL E4.</td>
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<td><strong>Taught competencies</strong></td>
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<td>063-0561-22L</td>
<td>Integrated Discipline HS22 in the Field of Design and Architecture (EIA)</td>
<td>W</td>
<td>3</td>
<td>2A</td>
<td>Lecturers</td>
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<td><strong>Abstract</strong></td>
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<td>Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.</td>
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<td><strong>Objective</strong></td>
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<td>The formal framework needs to be discussed with a chair within the institute IEA. The aim is a well-founded examination of a clearly formulated question.</td>
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<td>052-0513-22L</td>
<td>Spatial Concepts in Film and Architecture</td>
<td>W</td>
<td>1</td>
<td>1V</td>
<td>M. Bächtiger Zwicky, A. Gigon</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The course deals with spatial phenomena at the interface of film and architecture. The alternating influence of these two media will be analyzed, the dispositions of perception and effect will be compared and thus will sharpen the view for an architectural way of looking at space.</td>
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<td><strong>Objective</strong></td>
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<td>The examination of filmic space situations and performance discloses new perceptions of architecture which will be studied on behalf of film analyses and experimental topics. During the course space-effective creative means such as editing or framing will be introduced and discussed under perceptive aspects. Mediality within spatial perception can thus be integrated into a development of cultural history and leads towards a conception which goes beyond the limits of architecture and stimulates new processes of design.</td>
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</tbody>
</table>
New perceptions of architecture are studied on behalf of film analyses and experimental topics. During the course space-effective creative means such as editing or framing will be introduced and discussed under perceptive aspects. Medially within spatial perception can thus be integrated into a development of cultural history and leads towards a conception which goes beyond the limits of architecture and stimulates new processes of design.

**052-0557-22L**  
**BUK Construction Lab**  
Places are limited. Before registering you need the acceptance of the lecturers!

**Abstract**  
Using innovative materials, the students are shown the integral relationship between the construction process, planning and execution. With a focus on the interaction of conception and implementation, constructions and details for novel materials are developed and a field test is planned in self-made case studies.

**Objective**  
Understand the complex relationships between material, detail and built artifact. New artistic methods are designed, analyzed and applied from a deeper understanding of innovative building materials.

**Content**  
Phase 1: The analysis of innovative building materials aims at their application in construction thanks to experimental construction methods.

**Prerequisites / notice**  
Places are limited and visiting the introductory lecture is mandatory.

**052-0565-22L**  
**Formalistic Analysis of the Architecture of the Neo-Liberal Ideology**  
*This course is offered until end of HS22.*

**Abstract**  
Using a built example, the elective examines the architecture that produces the neoliberal ideology. Based on the method of historical building surveys, the formal-architectural properties are described, analyzed and finally summarized in the sense of a formal catalog of neoliberal architecture.

**Objective**  
The participants critically deal with contemporary urban and building production from a design perspective. By applying the method of the course, they learn the ability to describe and analyze the formal-architectural properties of architecture.

**Content**  
Instead of comprehending the complex planning processes and accepting the built as a consequence, the elective turns the analysis ‘head on its feet’: What kind of quarter, piece of city has been realized? If objects cannot lie (cf. Bulle, Heinrich: Handbuch der Archäologie, Munich 1913), the ideology can also be read from the architecture itself, provided that it is questioned methodically and precisely. Therefore, the elective is based on a formal-architectural analysis. The formalistic analysis refers to the scientific method of historical building surveys. In a first step the urban spaces, buildings structures, facades, entrances, etc. are described in detail in order to identify possible architectural principles and typological properties of the overall project in a second step. In a final step, the results from this formal-architectural analysis are summarized in the sense of a formal catalog of neoliberal architecture.

**Taught competencies**  
- Subject-specific Competencies: Concepts and Theories  
- Method-specific Competencies: Analytical Competencies  
- Social Competencies: Communication  
- Personal Competencies: Integrity and Work Ethics

**History and Theory of Architecture**
During what Okwui Enwezor called “the Short Century” of African independence, building activists published in ways that circumvented the need to use former colonial powers to reproduce knowledge. There were manuals on building in earth, experiments in fibre-based roofing, to act autonomously. The case studies it will explore, which are not well known beyond local circulation, will support us to devise and re-wilding, and bio-energy, amongst others. Given that this research area is distant in time and space, the seminar aims to build empathy in imagining and reacting to the dilemmas faced by activists and architects in the new Non-Aligned nations.

The ecological imperative forces architects to re-unite their design with sustainable construction. But architecture criticism also has to find new criteria in order to place buildings in light of their environment. Context-related aspects could be deduced from site visit. To this day, crimes are committed in the name of architecture. Therefore global trade chains and economic sectors that dominate the entire construction process will also be examined in this seminar – and participants are expected to have the courage to carry out investigative research.

Architectural criticism must develop new criteria in order to place buildings in the right relationship to the environment. In this seminar, the ecological view is particularly directed at concrete as a building material in order to clarify its criminal economy and aesthetic exaggeration. The ecological imperative forces architects to re-unite their design with sustainable construction. But architecture criticism also has to find new criteria in order to place buildings in light of their environment. Context-related aspects could be deduced from site visit. To this day, crimes are committed in the name of architecture. Therefore global trade chains and economic sectors that dominate the entire construction process will also be examined in this seminar – and participants are expected to have the courage to carry out investigative research.

In this seminar, investigative research, writing as a craft and journalistic strategies are tested and taught. Possible formats are studied on the basis of selected media and implemented in individual as well as collective work.
Representation of architecture is inextricably linked to photography since the mid 19th century. As buildings are commonly discussed on the basis of images, understanding their technical origin is key to reading and making them. By teaching students how to use a 4x5" view camera, the artist and photographer Tobias Wootton will introduce different techniques of 'thinking through the lens'.

Knowledge of architectural photography

History, theory and practice of photography in relation to architecture

This be-weekly course is taught in 2 groups of max. 15 students each, in English and German.

Course dates s. room reservations!
Group 1: Thursdays 16:00 - 20:00; Group 2: Fridays 14:00 - 18:00

Students will be selected on the basis of a motivation letter.
Deadline: 09.09.2022, 12:00 h, to wootton@arch.ethz.ch.
Please also state a preference which day suit you best:
Group 1: Thursday evening
Group 2: Friday afternoon

Course dates s. room reservations!
Students will be selected on the basis of a motivation letter.
Deadline: 16.9.22, 12:00 h, to wootton@arch.ethz.ch.

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**052-0823-22L** History of Art and Architecture

*Does not take place this semester.*

**052-0825-22L** Special Questions in History of Art and Architecture: Food for Thought

**052-0827-22L** Seminar History and Theory of Urban Design: Sites and Services

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**Abstract**

Dieser Kurs findet im HS22 nicht statt.

**Objective**

Dieser Kurs findet im HS22 nicht statt.

**Content**

How do we talk and write about food? What are criteria for good food? How does it relate to history, memory, money? In which spaces is food being produced?

In this seminar, we will eat and speak about home-made food, discuss with invited guests and read texts from the fields of history, theory, poetry and fiction.

How do we talk and write about food? What are criteria for good food? How does it relate to history, memory, money? In which spaces is food being produced?

For each session of the seminar, participants will bring home-made food (soup, cake, salad, stew, preserves, etc.).

They will tell the story of the food. The group will discuss it and talk about taste, aspect, quality, associations.

Invited guests (chefs, authors of cookbooks) will talk about their work.

We will read and discuss texts from the fields of history, theory, poetry and fiction.

This seminar is held in cooperation with Prof. Dr. Beate Fricke, Institute of Art History, University of Bern.

The sessions of the seminar will be held in diverse locations.

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Upon completion of the course, the students will have:

1. acquired a general knowledge of the role of architecture and urban planning in the historical context of development aid, the main actors involved, and strategies adopted;
2. acquired an in-depth knowledge on the specific housing paradigm of 'sites-and-services';
3. developed a critical attitude in engaging with the history of postcolonial urban design;
4. developed a theoretical understanding of the act of inhabitation as central to architecture and its history;
5. developed a reflective attitude on the modes of writing architectural history and the role of inhabitation in it;
6. strengthened their analytical skills by engaging in text- and project-based discussions, their collaborative skills in team-based project analyses, and their communicative skills in presenting the outcomes of their work to their peers.

The City Lived: 'Sites-and-Services'

In our seminar series 'The City Lived' we focus on the history of urban design with a particular emphasis on the lived experiences in the city. This semester’s seminar will focus on 'sites-and-services', which was an important housing paradigm that was mobilized in the context of development aid to provide cost-efficient housing for the global poor.

This housing strategy consisted of providing 'sites' – plots of land to construct dwellings on – in combination with a set of 'services', ranging from infrastructural features such as sewerage and waste disposal, to market-based interventions that aimed to make cheap building material more easily accessible or financial loan schemes that offered inhabitants the means to invest in their homes. It often operated on a large scale and targeted thousands of households in a single project. As it was heavily endorsed by major actors such as the World Bank and the United Nations for several decades since the 1970s as a cost-efficient way to relieve a high number of people from their most basic housing needs whilst simultaneously offering authorities the means to direct the enormous growth of spontaneous settlements in the urban peripheries, these 'sites-and-services' schemes have left a major imprint on many cities in the Global South. Despite this impact, their histories are not that well documented.

Since these were essentially unfinished projects that relied on their future inhabitants to complete their dwellings, in this seminar we not only intend to dig up the histories of such projects but also to discuss what we can learn from the histories of such atypical housing projects. Inhabitants have drastically expanded and transformed the initial minimal design to often unrecognizable degrees according to their needs and resources and many of these sites are now integrated into wider urban patterns. How do we write the history of 'unfinished' projects? How do we acknowledge the act of appropriation and inhabitation as integral part of such projects?

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The course will be graded as follows:

Active participation in the course: 20%

Active participation in the course involves the capacity of asking mature questions in response to lectures, critically discussing required readings during our discussion seminars and giving constructive feedback to fellow students during presentations.

Mid-term assignment: 30%
In small teams, students will present a collective presentation on one particular sites-and-services project, each outlining an individual research question they would like to focus on in the remainder of the semester.

Final assignment: 50%
The final assignment consists of two components: (1) an in-class presentation where in small teams students will present both a collective and individual presentation on one particular sites-and-services project; (2) a short individual written paper, pursuing a research question that reflects the individual student's interest in the topic.

**Taught competencies**

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<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Self-direction and Self-management</td>
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**052-0829-22L History of Art and Architecture: Special Topics**

Not eligible as a Compulsory GESS Elective for students of D-ARCH.

**Abstract**
Architecture Exhibitions

To exhibit architecture is an oxymoron. In architecture we need many tools to communicate a project to an audience. These evidences of architectural thought are used to "exhibit the architecture." Images, words and representations transmit ideas, concepts and ideologies and create shared meaning of things, which we will analyze and discuss.

**Objective**
See course description

To exhibit architecture is an oxymoron. In architecture we need sketches, drawings, models, plans, scribbles, videos, interviews, and renderings to communicate a project to an audience before and even after it is built. These evidences of architectural thought are used to "exhibit the architecture." Images, words and representations transmit ideas, concepts and ideologies and create shared meaning of things, which we will analyze and discuss. The object is to provide an imaginative space for the students to examine methods and relations between discourse and medium, context and institutional frameworks that inform representations of architecture in historical and contemporary practices.

**Prerequisites / notice**
Not eligible as a compulsory GESS Elective for students of D-ARCH.

**052-0833-22L PhD Teaching**

Does not take place this semester.

**Abstract**
The course discusses the material encounter of modern architecture and photojournalism as both converged to transform Brasília, the new capital of Brazil designed by Costa and Niemeyer, into a global mass media event. The photographic material produced for magazines promoted images of a new imaginary nation and staged dissonances and microhistories of this massive urban-architectural endeavor.

**Objective**
To understand the construction process of modern architecture's photographic representation in international mass media through the collaboration network between photojournalists, editors, illustrated magazines, photo agencies and new technologies.

To explore how photojournalism challenges the sterile photographic depiction of modern architecture's spaces. Instead of abstract conditions and no people, photojournalistic images perform a sort of 'offstage', introducing the construction site, everyday events, temporary settlements, imperfections, materials, maintenance, impacts on landscapes and communities.

To investigate the exploitative nature and colonial gaze of "humanitarian" photojournalism, and the search for the exotic in faraway lands.
Can we achieve gender parity in architectural historiography? Can we talk about equal numbers of women, men, and other gender identities when all textbooks agree that there simply were (much) more male architects than those identifying as female until very recently—and still are, if we accept the star system? What would shift, if we insisted on finding a woman with architectural agency for each man we are taught about? How would we find these women? In this course, we will explore what forms of agency woman had before 1900, focusing on her pen as her main tool. Writing and publishing allowed woman a public voice long before she was allowed to enrol for professional degrees or have the vote at the ballot box. She was not silent, and she had a lot to say about her environment. Her lived experiences and her skill to ascribe meaning to spaces for others to relive is as crucial to our understanding of architectural history as that of contemporaneous design practices. We must listen to her if we want to come closer to parity in architectural histories. This course will broaden students’ understanding of the modern age by challenging existing canons in terms of gender, class, race, and other social categorisations creating systems of oppression. Consisting of reading seminars and writing exercises, we will engage both with 18th and 19th-century primary sources as well as with feminist theory across the last 300 years, embedding these in the wider contexts to achieve parity. Writing is central to the course, both as primary source as well as a tool to develop our own engagement with architecture and its histories. Students will gain skills in historical research as well as with digital humanities tools. Concepts taught include situated writing, intensive/extensive reading as well as text mining and analysis. Students will be enabled to write their own histories, to take agency themselves in which ways they want to know about the past. Assignments will consist of several written pieces, produced during the semester, of differing length and format, both creative and academic, always closely linked to our joint research. The pieces will be peer reviewed in class to produce a collaborative response to the question: Can we achieve gender parity in architectural historiography?
Since the 1990s, there is a vivid discourse on “Artistic Research” – an artistic approach, which is characterized by different interconnections.

Class matters – in architecture, art and design

The participants gain familiarity with the analysis terms of historical cultural sociology and can apply them to questions of architecture and urban research.

The subject of this seminar is the relationship between architecture and social class. Our inherited class reference determines our social architecture: how we relate to each other in a historically grown, hierarchically structured space, how we perceive the built world, how we intervene in it in a creative way and how we judge sensuality and beauty, all of this is strongly pre-structured and yet leaves nothing to be desired leeway open. We can’t help what class we’re born into, but we can understand, mediate— and maybe even change— the social reflexes and unconscious beliefs that arise out of this coincidence. This seminar offers a sociological, historical and aesthetic basis for this.

- On the basis of theoretical texts, a number of questions are discussed: How is the racialization of the working class manifested in the history of cultural production? How are economic discrimination and privilege in the field of the arts related to normative gender categories?
- How do we make the big analytic terms our own when we write about class and architecture to connect with others?
- Exercises on graphical representations of social strata. What is a spatial perspective considering the creativity of class habitus? How can we present the fragments of our perception, determined by class origin, as a whole without leveling or even condemning individual positions?
- How do we deal with the naturalized power of imagery’s common sense when representing class issues in architecture?
- Personal engagement with autobiographical photo material regarding the manifestation of the habitual, inherited lifestyle of a certain milieu or a certain class faction - or regarding the manifestation of the break with this heritage. Approaching the answer to the question: What makes the difference – or, how do I make the difference - between a narcissistic and an objectified architectural view of social space?

052-0845-22L Reflection on Exhibition and Art Practice Now

Does not take place this semester.

This course is limited to 20 participants.

Enrollment on agreement with the lecturer (s. course description)

052-0851-22L Topical Questions in History and Theory of Architecture: (Un)settling Territory

This course poses the question of how projects of land, terrain, and territory enfold laboring bodies and gather around, legislate, and flow through settlement. In this seminar, we will explore the architectural and planning mechanisms and attendant regimes of visibility through which specific forms of territorial orders have been materialized, represented, standardized, and maintained.

(Un)settling Territory: Landscape and Colonization.

Through engagements with Indigenous spatial ontologies and Black feminist practices of postcolonial counter-mapping, we will trace the ways in which those territorial orders have been disrupted, unsettled, and re-imagined. Focusing on the relationship between the landscape and colonization, we will begin with an analysis of places where “discovery,” land clearance, transplantation, and settlement belong to the same exploratory processes. This dynamic, fundamental to imperial and colonial structures and to their territorialities, has been central to the development of modern architecture. Working with an interdisciplinary and intersectional approach and privileging marginalized voices, we will explore this development with perspectives offered by recent movements in Black studies, critical feminist geography, Indigenous environmental history, and multispecies studies. Engaging these perspectives serves to unearth the material and infrastructural crossings of space and power and reveals long-standing but overlooked entanglements between land and architecture.

Certain territorial formations such as the plantation and the colony, including their corporate industrial afterlives, share a common heritage informed by the same recurring themes that define the Anthropocene, a subject of increasing scrutiny within studies of the built and landscaped environment. Those themes include entrenched forms of racialized violence, land alienation, environmental degradation, and large-scale species loss—narratives of modernity and its modernisms embedded in the land and landscape. Thinking alongside Kathryn Yusoff and following the mobile, ephemeral, and “small spaces” of empire, we will ask how the grammar of colonization, broadly conceived, has shaped the extractive economies of life on earth.

Please note:

- Around 4-5 meetings will take place outside ETH Hönggerberg and some at Graphische Sammlung ETH Zürich in the main building. Time for travel before and after the meetings is therefore necessary.

The seminar is limited to 20 people. There will be a waiting list.

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(Un)settling Territory: Landscape and Colonization.

Through engagements with Indigenous spatial ontologies and Black feminist practices of postcolonial counter-mapping, we will trace the ways in which those territorial orders have been disrupted, unsettled, and re-imagined. Focusing on the relationship between the landscape and colonization, we will begin with an analysis of places where ‘discovery,’ land clearance, transplantation, and settlement belong to the same exploratory processes. This dynamic, fundamental to imperial and colonial structures and to their territorialities, has been central to the development of modern architecture. Working with an interdisciplinary and intersectional approach and privileging marginalized voices, we will explore this development with perspectives offered by recent movements in Black studies, critical feminist geography, Indigenous environmental history, and multispecies studies. Engaging these perspectives serves to unearth the material and infrastructural crossings of space and power and reveals long-standing but overlooked entanglements between land and architecture.

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This course is aimed at students from the 5th semester onwards. It will require a set amount of reading and sessions will include intensive discussion and in-class exercises, so consistent attendance is very important.

052-0853-22L  Architecture Beyond the Studio: Reflecting the Social Dimension of Design

The course is limited to 25 participants.

This course is offered until end of spring 2023 semester.

Abstract

“Architecture beyond the studio” is a seminar with the aim to reflect and rethink the formal and spatial aspects of the students’ own design projects from the perspective of the Humanities and Social Sciences (HSS). Literature from the HSS is researched individually, related to the design projects in the form of a paper and presented jointly in an exhibition.

Objective

In this seminar students learn to critically reflect their practice as architects from the perspective of the humanities and social sciences (HSS). As object for these reflections serves one of the students’ own design projects. This can be an architectural project they have designed at a chair for architecture and design, an architectural practice or independently.

The main focus of the seminar lies on identifying a spatially and architecturally clearly defined aspect within the students’ design projects and in reflecting as well as deepening one’s own understanding of this aspect. By writing texts alienating architectural plans and images of their design projects and establishing an individual collection of architectural examples, the students learn to relate their own design practice to research of the HSS as well as the built environment.

At the end of the semester, the students will be able to identify the historical, political sociological and/or economic dimensions of the architectural aspects in their design project as well as to locate these aspects in a contemporary architectural and HSS discourse. Furthermore, they learn to develop an individual conceptual position towards architectural-spatial questions and to communicate them visually and verbally.

Currently, the discipline of architecture is undergoing substantial change. Political and social aspects are again becoming more important within the profession of architecture. In the 1980s and 1990s architects legitimized their designs by recurring to their artistic abilities and individual ingenuity. Today, however, practicing architects cannot escape the social and political responsibility that comes with the design of architectural buildings. An increasing number of public as well as private developers expect architects to include considerations about the social and cultural life of prospective inhabitants in their architectural designs.

Against this background, the seminar “Architecture beyond the Studio” bridges the gap between architectural design and the Humanities and Social Sciences (HSS). Supported by two lecturers – with backgrounds in architecture and the social sciences – the students develop texts in which they critically reflect on spatial aspects in one of their own design projects from the perspective of the HSS.

The aim of this seminar is to enable students to better understand social, political and/or historic dimensions of spatial aspects in their architectural designs. The students’ tasks include reflexive and analytical writing, the presentation and discussion of these reflections, literature research and the production of a final text, in which they summarize their most important findings and define a theoretical position that could guide their future work as designers.

Taught competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analystical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Adaptable and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Method-specific Competencies

Not assessed

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063-0861-22L  Integrated Discipline HS22 in the Field of History and Theory of Architecture (GTA)

Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.

Abstract

Works in the integrated discipline art and architectural history evolve in close connection with projects in design. Textual and creative works are possible. The length of the text or the extent of the creative project will be decided upon individually. Interested students are asked to develop a (textual or diagrammatic) concept sketch explaining the content and the form.
We expect that students pursue their examination of the design process independently and in an original manner or that they develop a related theme from the perspective of the history of art and architecture. The work should be part of the design process and interact with it formally and in regard to content.

Works in the integrated discipline art and architectural history evolve in close connection with projects in design. Textual and creative works are possible. The length of the text or the extent of the creative project will be decided upon individually. Interested students are asked to develop a [textual or diagrammatic] concept sketch explaining the content and the form.

**052-0835-22L**  
*Summer School: Tentacular Writing - A Peer-to-Peer Writing Retreat (ETH-EPFL)*  
*For MSc ARCH students and Doctoral students.*

**Abstract**

The summer school intends to renegotiate and experiment with the ways we – as researchers and spatial practitioners – perform writing, as a format and as a practice. In the set-up of a collective retreat in the Swiss Alps, in a non-hierarchical learning format, a group of peers is invited to shape an academic community, work alongside and discuss their work-in-progress informally.

**Objective**

The summer school aspires to establish a peer group of early-career scholars that stay connected beyond the summer school. By the end of the workshop, the participants will have:

– acquired skills on new writing methods
– discussed learning and writing outcomes collectively
– gained the opportunity to take the role of an editor of their colleagues work
– gained experience in presenting their work-in-progress in an informal setting

The programme foresees a summer school in the form of a collaborative writing retreat. The participants are expected to take their individual research as a starting point and develop it further during their stay. Selected invited experts will host writing workshops on themes like creative writing, site writing and multi-perspectival writing. Additionally, two sensorial workshops hosted by artists on the themes of sound and smell aim to inspire and enrich the writing practice and connect the participants to the place. All workshops will serve as input sessions and are followed by individual writing periods, where participants get the chance to test the methods acquired in the expert workshops. Individual writing sessions are then followed by group sessions where the material is collectively discussed. The format aims at generating a non-hierarchical learning environment, a peer group where colleagues collectively progress their writing by exploring new methods and perspectives.

The summer school is articulated through the synthesis of three different formats:

– workshops organized by external guests offering inputs to the participant
– individual writing sessions for the participants to develop their material
– collective peer-to-peer discussion aiming at exchange and the formation of a peer-group

**Writing Workshops**

**Room and Field, Writing One with Another: a Site-Writing Workshop**

with Jane Rendell and Polly Gould

**Exploring Sensorial Practices**

Writing with sound, by Ludwig Berger, sound artist

Follow your nose, by Curdin Tones, community-artist

**With Collective Cooking Sessions and Fountain Bathing curated by the community-artist Curdin Tones**

Teaching involves 3 full workshop days, 1 self-study day and one final review day.

**Place:** The summer is organized at the Alpine village of Tschlin in Graubünden, Switzerland. Participants will be hosted at three local houses. Common workshops will be organized at the venue of the local school and at the artistic residency space of Somalogs/74. The summer school explores a form of inhabitation that is neither touristic nor individual and allows for reflection and redefinition of what it means to retreat: We want to see retreating not as isolating and detouching but rather as engaging with localities and situating ourselves. The summer school articulates through the synthesis of three different formats:

– workshops organized by external guests offering inputs to the participant
– individual writing sessions for the participants to develop their material
– collective peer-to-peer discussion aiming at exchange and the formation of a peer-group

**Writing Workshops**

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**With Collective Cooking Sessions and Fountain Bathing curated by the community-artist Curdin Tones**

Teaching involves 3 full workshop days, 1 self-study day and one final review day.

**Date:** The summer school will take place on 11 – 16 September 2022.

**Organisers**

Metaxia Markaki (ETHZ), Johanna Just (ETHZ), Sila Karatas (EPFL)

**Prerequisites / notice**

Participation fees cover accommodation and selected meals (all lunches and 2 dinners):

250CHF (ETHZ/EPFL doctoral students),

350CHF external doctoral students; ETHZ/ EPFL Mittelbau with a strong interest in writing. All participants are required to take part in the full 6 day programme. (Arrival 11.9, programme 12-16.9) Applicants will submit a writing sample related to their dissertation and a CV.

**Taught competencies**

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The word photography combines Greek roots phωτο-, meaning "light," and graphē, meaning "to draw," or "represent by drawing lines." Photography is essentially "drawing with light."
Objective

Through a combination of practical exercises in video and audio techniques in parallel with the study of seminal observation-driven texts, this course aims to equip students with the basic tools and core principles to create short but complex portraits of urban space. This semester, the focus falls the the topic of daylight, in all of the ways in which it affects everyday life - both indoors, outdoors, and everything in between.

This approach will be applied to experiments in filmmaking and photography. Through various audiovisual experiments, students will collectively speculate on ways to marry the various forms of research methods that traditionally do not intersect, creating mosaics of experimental research forms.

Using widely available recording tools and editing software, students will turn their fieldwork into short video or audio works of about 3-5 minutes.

Content

The course will compose of lectures, practical crash courses in media use and storytelling, and fieldwork sessions. The course will be a laboratory in the creation of short media works that aim to inform the architectural design process, working between the city and the studio in ONA. Students will be expected to complete all required work within the hours that the elective meets, with few requirements outside of the class hours.

Literature

Seminal texts include:

- ‘Cross-Cultural Filmmaking’ (Barbash, Castaing-Taylor)
- ‘Acoustic Territories’ (LaBelle)
- ‘Ethnography: Principles in Practice’ (Hammersley, Atkinson)
- ‘Thick Description: Toward an Interpretative Theory of Culture (Geertz)

Taught competencies

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<th>Subject-specific Competencies</th>
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063-0761-22L Integrated Discipline HS22 in the Field of Landscape and Urban Studies (LUS) Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.

Abstract

Design concepts ranging from architectural objects to urban planning are developed together with the discipline of landscape architecture. Dependent on the task at hand different themes are investigated. The goal of the integrated discipline is to develop design solutions of a specific topic in landscape architecture, which have to be incorporated into the overall design submission.

Objective

Students gain an insight into the integrated disciplins of design in architecture together with landscape architecture.

Content

Design concepts ranging from architectural objects to urban planning are developed together with the discipline of landscape architecture. Dependent on the task at hand different themes are investigated. The goal of the integrated discipline is to develop design solutions of a specific topic in landscape architecture, which have to be incorporated into the overall design submission.

052-0713-22L Serendipity: Zurich Pointcloud Video 

Number of participants limited to 16 (due to technical equipment).

Course language: English or/and German

Abstract

Curating the Zurich with Point Cloud Video Animations. The Wahlfach Serendipity will investigate various sites in Zurich through the point cloud model archive available at the Chair of Prof. Christophe Girot. Students will select specific sites and the corresponding material in the archive to create short audiovisual animations.

Objective

The goal of the Serendipity Wahlfach is to enable students to develop skills in point cloud modelling integrating both sound and video techniques. Students will learn digital modelling together with sound and video techniques at the Media Lab of the Chair of Prof. Girot. This will allow them to select, imagine and present selected environments in short videos. The video installations will be assessed for their capacity to reveal the intricate complexity of the urban realm in Zürich. Through the use of precise modeling techniques based on laser-scanned data, students will learn to move iteratively towards a final video proposal of the site they have chosen that will compound topography, infrastructure and architecture. The final works will be part of a larger D-ARCH event combining video works from different periods ranging from the 1970’s until today. It will strengthen student’s knowledge about digital and video approaches while still considering the broader socio-ecological context of Zurich’s underground.
Content

The Department of Architecture at the ETH through the Media Lab and LVML represents one of the longest standing laboratory in video and virtual representation in architecture in Europe. The question of environmental representation in landscape and architecture is still a burning question at the heart of a rapidly changing education. The capacity to visualize and assess both what is above ground and what is underground is going to grow in significance, as urban settlements become more concerned with the physical reality to which they belong.

This new approach to the underground modeling of existing buildings is opening new possibilities in contemporary architectural thinking. It addresses directly the capacity of the city of Zurich to cope with and accept its own underground realm. As a result, the underground realm revealed by student videos through selected point cloud models will reinforce the sense of a new reality to be tackled and integrated. Many of the underground realms constructed by our predecessors where not originally meant to be looked-at or to be understood as objects of aesthetic consideration. Most of these functional spaces were meant to be buried below the urban fabric and forgotten. The Wahlfach Serendipity will challenge the dominant attitude that has sought to hide the underground away from sight for so long. It will give students the opportunity to produce a video installation that will integrate the underground in a broader framework of architectural acceptance.

The video installations will open the debate about existing underground structures and their meaning in contemporary society.

This Wahlfach will propose a series of short workshop in digital modelling methods, video and sound, that will be adapted to the point cloud archival material at hand at the Media -Lab. The intention is to develop navigation skills in modelling that will be reflected in the videos. This will be achieved through the enhanced capabilities of 3D point cloud modelling and design at the LVML (Landscape Modelling and Visualizing Laboratory). The individual videos may draw from a combination of navigational methods to find the best adaptive solutions.

These tools will be supported by the Media Lab team that will provide feedback, analysis and visualizing processes. The Zurich underground video scenarios developed by the students will be regularly assessed and improved in their performance and feasibility. These new underground video installations will be integrated in a larger event at HIL covering 50 years of video teaching at D-ARCH. The philosophy of the serendipity Wahlfachis is to build on the strengths of the current archival material at hand and to reveal aspects of the underground still to be discovered and enhanced. The Wahlfach will aim at bridging the realms of architectural design and media, by promoting novel ways that will transform our vision and understanding of the Zurich underground.

Objectives/notice

This elective gives students the opportunity to expand their knowledge in the area of landscape architecture.

The elective course Topology in HS 2022 deals with the theory and perception of landscape architecture, focusing on current debates.

The transience of human actions contrasts with the constant pulse of natural (physical and biological) processes, such as the growth of trees, the erosive force of the wind, the folding of mountains. In one place, movements of the most different dimensions meet, detach from each other or flow together. We humans have long since become part of these complex choreographies: We adapt the environment to our needs and thereby inscribe new flows of movement, rhythms and forms into the (urban) landscapes.

In this elective, dynamic aspects of landscape morphology are explored in different ways. How do we as architects orient ourselves in transcalar processes? With a selection of texts and films we dive into the topic and examine significant positions from dance, art and landscape architecture. In intense mini-workshops we will go into the landscape ourselves and test the relations of our own bodily movements to the space.

Abstract:

- Capture and analyse the past and present; design, present and discuss future living spaces in 4D.
- Read, understand, deconstruct and formulate new zoning and building rules (BNO)s.
- Set up an ArcGIS Urban model and integrate current and new urban rules and visualize/simulate development scenarios/ variations of urban designs.
- Learn from students from different disciplines through teamwork and by peer-reviewing each other's work.
- System thinking through causal loops.

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<td>Critical Thinking</td>
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<td>Reader</td>
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<th>4D-Geodesigning Urban Transformation - Summer School</th>
<th>W+ 3 credits</th>
<th>7G S. Wälty, H. Klumppner</th>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 101 of 2345
Can architecture, urban design and planning contribute to make housing and cities more equitable and inclusive? Answers to this question are the focus of this course. The course consists of a lecture series providing some fundamental knowledge in natural environment with experts and academics from various disciplines such as geology, climate, ecology, soil and plant sciences. The active participation in discussions following presentations allows participants to tackle relevant challenges in the natural environment with academics and experts as well as to exchange ideas amongst the participants.

### 052-0732-22L Housing Issues and Challenges in the Global South: Contributions of Architecture

**Abstract**
Can architecture, urban design and planning contribute to make housing and cities more equitable and inclusive? Answers to this question will be provided by socially engaged architects from Europe, Asia and Latin America through the presentation of concrete actions and projects.

**Objective**
The course aims at raising awareness about the multi-faceted manifestations and consequences of neo-liberal housing and urban policies. After a general introduction to the causes and consequences of the current global housing and urbanisation challenges, the students will learn through concrete examples that architects, planners and urban designers can make a difference. Socially engaged architects, designers and planners from Europe, Asia and Latin America will present actions and projects that contributed to make human settlements more inclusive, liveable and sustainable.

**Content**
The course will focus on the following topics:
- Global housing and urban challenges: an introduction
- From planning to actions against the commodification of public spaces in Vienna
- Countering the financialization of the city of Berlin
- Un-gating the city: the case of Bogota, Colombia
- Creating public space for popular culture in Barranquilla, Colombia
- Designing lights and sites of publicness in Mali
- Architects’ role in ensuring informal settlers’ right to the city in Bolivia
- Architectural activism and the re-emergence of housing cooperatives in Spain
- Enhancing social inclusion through participatory urban design in Milano, Italy
- Urban environmental activism, architecture and housing cooperatives in Switzerland
- Learning from vernacular building practices in India and Latin America
- Rebuilding housing and communities after conflicts and disasters
- Architecture for reconciliation and peace building in post-conflict settings

**Lecture notes**
A course overview including lecture summaries is made available to inscribed students prior to the start of the semester.

**Literature**
A bibliography will be made available to inscribed students prior to the start of the semester.

### 052-0733-22L Introduction to the Fundamentals of Natural Environment

**Abstract**
This course is suitable for MSc and MAS UTD students only!

**Objective**
Participants become acquainted with relevant issues and topics about the natural environment and gain valuable insights into the interaction of all living and non-living things, climate, weather and natural resources. The active participation in discussions following presentations by invited lectures stimulates critical thinking and allow participants to tackle relevant environmental challenges and discuss opportunities with academics and experts as well as to exchange ideas amongst the participants.

**Content**
This course is a series of lectures by academics and experts who present their research and fundamental knowledge across the field of the environmental sciences (geology, climate, ecology, soil and plant sciences). The active participation in critical discussions following each presentation allows participants to tackle relevant challenges in the natural environment with academics and experts.

**Lecture notes**
More details about each lectures, as well as keywords and topics relevant for and discussed during the lectures are published in advance on the course web page: mscla.arch.ethz.ch

**Prerequisites / notice**
No previous knowledge in environmental sciences is required.

### Technology in Architecture

#### Number Title Type ECTS Hours Lecturers

| 101-0587-00L Workshop on Sustainable Building Certification | W | 3 | 2G |

**Abstract**
Building labels are used to certify buildings and neighbourhoods in term of sustainability. Many different labels have been developed and can be used in Switzerland (LEED, DGNB, SNBS, Minergie, 2000-Watt-Sites). In this course the differences between the certification labels and its application on 3 emblematic case study buildings will be discussed.
After this course, the students are able to understand and use the different certification labels. They have a clear view of what the labels take into consideration and what they don't. This three-building case study will be presented.

Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

Subject

1. Introduction

- Basic knowledge of moisture transport and related degradation processes in porous materials
- Knowledge of experimental determination of moisture transport properties
- Knowledge of pore network model and application to two-phase invasion percolation simulation
- Application of knowledge to moisture transport in cracked materials and flow in deformable porous media

2. Moisture transport: theory and application

- Description of moisture transport
- Determination of moisture transport properties
- Liquid transport in cracked materials, flow and transport in deformable porous media

3. Pore network model: theory and application

- Liquid transport in cracked materials, flow and transport in deformable porous media
- Single- and two-phase pore network model: quasi-static and dynamic
- Exercise on quasi-static two-phase pore network model: invasion pattern, capillary pressure curve
- Application of pore network model in two-phase transport

101-0577-00L

Abstract

An Introduction to Sustainable Development in the Built Environment

In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict.

At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods

- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:

- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world

Synthesis: Transition to sustainable development

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
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<td>Building Process: Realization</td>
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<td>W</td>
<td>M. Eglin</td>
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<tr>
<td></td>
<td>The course is limited to 40 students. Enrolment is only possible in agreement with the lecturer (<a href="mailto:eglin@arch.ethz.ch">eglin@arch.ethz.ch</a>).</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Visits to construction sites and interdisciplinary lectures on the topics of communication, complexity, landscape and investment are the main focus of the workshop. In addition, the term process is to be depicted by means of visits to manufacturers of construction components.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>The main focus of the diploma elective subject is in showing the building process by means of current examples of urban design with architectural relevance. The Chair views itself as the facilitator between those involved in construction and students. Active participation is a prerequisite.</td>
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<td><strong>Content</strong></td>
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<td><strong>Lecture notes</strong></td>
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<td>The recordings of the lectures are available on the MAP under the link <a href="https://map.arch.ethz.ch">https://map.arch.ethz.ch</a> (book symbol at the top right).</td>
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<td>The number of participants is limited and enrolment is only possible in agreement with the chair!</td>
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<td>Introductory event: Participation in the introductory event is a prerequisite for this course!</td>
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<td>Structure (Lectures, field work, final presentation) will be communicated in time.</td>
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<td>052-0627-22L</td>
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<td>W</td>
<td>H. Palmer</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Architecture is already saturated in images. To properly articulate the digital cosmos of today what we need is writing and code. The problem addressed in this course is how to allow the digital cosmos to find its voice, and how you as architects can inhabit this voice to speak both freely and carefully, both playfully and seriously, from word-building to world-building.</td>
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<td>No creative writing experience is required; you can forget everything you have learned. We will use experimental writing modes, movements and exercises to find ways to develop agility and grace in writing by testing the motility of concepts such as light and matter, gravity and grace, night and day.</td>
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<td><strong>Content</strong></td>
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<td>You will form your own voices, forms and styles. We will all start with the initial theme of saturation. The digital cosmos is saturated. Saturation is extreme. Saturation is overwhelming. Saturation is beyond what is required.</td>
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<td><a href="http://www.caad.arch.ethz.ch">http://www.caad.arch.ethz.ch</a></td>
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<td>A. Schlüter, E. Borkowski</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>This Online course provides an introduction to climate-responsive design using the Hive tool and how to apply it in early building design stages. Hive allows architecture and building science students to understand the relation between architectural design, climate, comfort and energy. Hive is a plugin for the 3D modeling environment Rhino and its visual programming interface Grasshopper.</td>
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<td><strong>Objective</strong></td>
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<td>• Recall general principles of climate responsive design and examples of it.</td>
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<td>• Utilize 3D building geometries to conduct simplified energy demand and supply simulations.</td>
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<td>• Observe relevant physical principles and interactions between climate, energy and geometry.</td>
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<td>• Implement passive and active concepts for Climate Responsive Design.</td>
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<td>• Apply Hive for building design analysis and integrate it into own designs or in design courses.</td>
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<td></td>
<td>• Identify and harness synergies and trade-offs between climate, energy and architectural design aspects.</td>
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<td>The course can be frequented individually, or as a prerequisite for other courses such as the master course Climate and Energy Systems 3 or architectural design studios.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>A working Rhino 6 or 7 license is necessary.</td>
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<td>1. Course overview.</td>
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<td>2. Introduction to climate responsive design.</td>
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<td>3. Introduction to Rhino, Grasshopper and Hive.</td>
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<td>4. Early solar analyses.</td>
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<td>5. Passive Solar Design (e.g. Fixed and movable shading).</td>
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<td>6. Active Solar Design (e.g. Using Photovoltaics).</td>
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<td>7. Real-world Applications and Examples.</td>
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<td>This is a blended-learning self-paced ONLINE COURSE that can be started at any time.</td>
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<tr>
<td>063-0661-22L</td>
<td>Integrated Discipline HS22 in the Field of Technology in Architecture (ITA)</td>
<td>3</td>
<td>W</td>
<td>Lecturers</td>
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<td>Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This part of the curriculum addresses design work in different areas of architecture and urbanism and integrates the knowledge acquired in previous years. It involves the active participation of specialists from the chairs of the institute ITA.</td>
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<td><strong>Objective</strong></td>
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<td>Understanding of the importance of the ITA disciplines for architectural design and integration of structural thinking into the design process.</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 104 of 2345
Abstract
The seminar investigates a long term tradition of modeling in architecture dedicated to measure building’s technical performances. Through weakly readings and class discussion, we will explore different ways to experience architecture at little scale. Conveying virtual and empirical tools, aesthetic and technical goals, the practice of modeling allow a transversal reading on architectural history.

Objective
Enlarge a background of historical knowledge and architectural culture. Developing a critical reflection on techniques of representation. Importantly bring to attention the value of fabricating in the process of architectural conceptualization.

Content
The seminar focuses on the fabrication of architectural models not just as miniaturized buildings, but rather as ways to observe their environmental proprieties. Each year, a particular aspect of environmental sciences will be studied. Starting from the realm of architectural acoustics, we will observe, on the one hand, various ways of testing the behavior of sound within reduced models. From the schlieren photographies, allowing a material visualization of sound, to the 1:10 acoustic models, going through the ripple tank and light beam methods, an empirical tradition of reduced built volumes allowed the study of sound reflection. On the other hand, we will explore how digital tools, through parametric modeling, allowed virtual simulations of architectural projects. Both methods offers ways for technically anticipating and theastic the result of architecture by synthesizing the complexity of a built project and connecting with a nineteenth century tradition of technical models conceived for experiencing building performances. Despite a shared way of thinking, virtual and empirical tools are nowadays used in a complementary way: the friction between these two approaches will be the overall object of the seminar.

Historic Building Archaeology and Conservation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0911-22L</td>
<td>Repair: Keep in Place</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>S. Langenberg</td>
</tr>
<tr>
<td>Abstract</td>
<td>Complex constructions that are difficult to maintain and industrial manufacturing processes decrease the lifespan of objects not only in product design but also in architecture. Repairability is becoming less of a concern – replacement seems to be the norm. We need to rethink the way we build, starting already with the planning phase.</td>
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<tr>
<td>Objective</td>
<td>In this course, we combine traditional topics of preservation with concepts of repair and FAB initiatives to raise awareness for sustainable thinking and action. Students will learn both traditional and digital methods as well as the basic building and material criteria for repair. The objective is not only the hands-on repair of a building part but especially to learn about the concepts of heritage preservation.</td>
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<tr>
<td>Content</td>
<td>The elective course will discuss and examine the reparability of constructions and building systems. Students will identify building parts in need of maintenance and subsequently develop a repair concept. In groups, they will carry out the repair under expert guidance or possibly with the aid of digital fabrication processes. The objective is to recognize and analyze mechanisms of deterioration and to propose adequate repair measures.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Baier, Andrea u. a. (Hg.), Die Welt reparieren, Bielefeld 2016.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Krebs, Stefan u. a., Kulturen des Reparierens, Bielefeld 2018.</td>
<td></td>
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<tr>
<td></td>
<td>Langenberg, Silke (Hg.), Repair, Encouragement to Think and Make, Berlin 2018.</td>
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</tr>
<tr>
<td>Prerequisites</td>
<td>ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h: Room: HIB Open Space 2 (HIB E52) or online. Zoom link: <a href="https://ethz.zoom.us/j/6684810727">https://ethz.zoom.us/j/6684810727</a></td>
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<tr>
<td></td>
<td>Langenberg, Silke (Hg.), Repair, Encouragement to Think and Make, Berlin 2018.</td>
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</tr>
<tr>
<td>052-0913-22L</td>
<td>Preservation: A Future for whose Past?</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>S. Langenberg</td>
</tr>
<tr>
<td>Number of participants limited to 40.</td>
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<tr>
<td>Abstract</td>
<td>A Future For Whose Past? The focus is on the heritage of minorities, marginalised groups and people without a lobby. This rarely considered heritage will be explored theoretically and practically through excursions, meetings and readings. The aim is to develop a concept and mediation formats for an international exhibition in 2025, the 50th anniversary year of the European Heritage Year 1975.</td>
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<tr>
<td>Objective</td>
<td>The students gain insight into the most important theories and practices of monument preservation and ways of conveying and exhibiting them. Through the examination of a self-selected topic, questions can be deepened and discussed in the group. The learning objectives in this semester are critical questioning of heritage and inventory, strengthening of mediation skills and the consideration of architecture and urban development in cultural-historical, sociological and economic perspectives.</td>
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<tr>
<td>Content</td>
<td>In monument preservation, too, the existence of a &quot;mainstream&quot; and a lack of inclusion have been criticised. This is particularly visible in the post-colonial UNESCO World Heritage status of 1,154 sites, of which only about a hundred are in Africa, but almost 600 are in Europe. But at the national level, too, there is a need to discuss whether the sites protected by monument, nature and heritage conservation laws in the German-speaking and thus preserved for the future actually represent history and the past. Whose heritage are we talking about, who determines what is important for society's memory and with which heritage a society identifies?</td>
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<tr>
<td></td>
<td>Gender and Heritage, Performance, Place and Politics, ed. by Wera Grahn and Ross J. Wilson, London/New York 2018</td>
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</tr>
</tbody>
</table>
### Taught competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

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

#### Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Taught competencies

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

#### Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Methods of Building Surveying

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Media and Digital Technologies</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Self-direction and Self-management</td>
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<td></td>
<td></td>
<td></td>
<td>Negotiation</td>
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</tbody>
</table>

The elective subject "Methods of Building Surveying" covers surveying and measurement methods ranging from simple hand measurements and tachymetry to laser scanning, terrestrial and drone-based photogrammetry (structure from motion) and other non-invasive assessment methods such as thermal imaging. The different methods and technologies will be presented on the basis of current or completed research projects and their practical applications will be discussed. Internal and external guest speakers will report on their latest research projects in the field of building research and construction history. In the course of the elective, students will also have the opportunity to try out the methods themselves and integrate them into a small concluding project of their own.

The course is composed of theoretical and practical parts in and outside the classroom. Will be announced in the course for the individual lectures.

### Literature

- Taught competencies

### Focus Works

*see Architecture MSc "Focus Work"

### Seminar Weeks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>051-0911-22L</td>
<td>Seminar Week Autumn Semester 2022</td>
<td>W</td>
<td>2</td>
<td>3A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

The seminar week is obligatory for students of all semesters. There are many and varied study contents. The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

### Science in Perspective

*see Science in Perspective: Type A: Enhancement of...*
## Language Courses

*see Science in Perspective: Language Courses ETH/UZH*

### Architecture Bachelor - Key for Type

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

### Key for Hours

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

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Architecture Master

Core Courses

Field of History and Theory of Architecture

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>063-0313-22L</td>
<td>History of Art and Architecture V: Caractère (Character)</td>
<td>W</td>
<td>1 credit</td>
<td>1V</td>
<td>M. Delbeke, S. de Jong, N. Magouliotis</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course is a reading class in which the architectural category of 'caractère' or character - a key concept in the 18th century but of great relevance until today - will be examined by a close reading of several key texts, from the late 1700s up until today. Independent reading and vivid discussion in class make up this course's character.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Deepen basic knowledge, improve ability to critically read and analyze texts of architectural theory, and understand shifts in architectural thinking.</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>'Caractère' or character is not only a quality applied to human beings. It is also a category of architectural discourse, developed in the 18th century when architects and theorists were seeking new ways to talk about and judge buildings, pushing architectural discourse beyond Vitruvian categories to which it had been tied for centuries before. This reading class will closely examine key texts that discuss the phenomenon of a building's 'character' from the 1700s up until today. The weekly assigned texts (in the original French, English or German) will be read at home and then discussed in class. Independent reading and vivid participation in class are a fundamental prerequisite. In addition, there will be weekly written assignments, which will all be graded. A final written assignment at the end of the semester will be graded as well. To pass the course, students will have to read each assigned text, and hand in all written assignments on time.</td>
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</tbody>
</table>

| 063-0801-22L | History of Art and Architecture VII | W    | 2 credits | 2V    | C. Rachele                     |
| **Abstract** | Imagining History and Inventing Architecture |
| **Objective** | Deepen basic knowledge, improve ability to critically analyze architectural history texts, develop humanities-based reasoning and argument skills, especially persuasive writing |
| **Content** | In the Renaissance, the practice of architecture fundamentally transformed into the design-based discipline it is now largely assumed to be. Both then and especially in nineteenth- and twentieth-century architectural history, this change was understood in opposition to "good" and "bad" models. This course investigates Antiquity and the Middle Ages as variously fashioned in the mind of the architect and the architectural historian. How does our understanding of these periods inform our thinking about the use of history for the contemporary architect? |
| **Literature** | Scans of the weekly readings will be made available on the course website. |
| **Taught competencies** | **Subject-specific Competencies** |
| | Concepts and Theories | assessed |
| | Techniques and Technologies | assessed |
| **Method-specific Competencies** | Analytical Competencies | assessed |
| | Decision-making | assessed |
| | Media and Digital Technologies | not assessed |
| | Problem-solving | assessed |
| | Project Management | assessed |
| **Social Competencies** | Communication | assessed |
| | Cooperation and Teamwork | not assessed |
| | Customer Orientation | not assessed |
| | Leadership and Responsibility | not assessed |
| | Self-presentation and Social Influence | not assessed |
| | Sensitivity to Diversity | assessed |
| | Negotiation | assessed |
| | Adaptability and Flexibility | assessed |
| | Creative Thinking | assessed |
| | Critical Thinking | assessed |
| | Integrity and Work Ethics | assessed |
| | Self-awareness and Self-reflection | assessed |
| | Self-direction and Self-management | assessed |

| 063-0807-22L | History and Theory of Architecture IX: Coming Home | W    | 1 credit | 1V    | M. Gnehm                     |
| **Stories in Architectural Theory** | The lecture course discusses architecture and literature in its diverse relations: Stories as moments when architecture comes to life, the writing of architectural history and theory and literary writing. The focus aims at the notion of home and its discontents. |
| **Abstract** | Coming home has dubious connotations in wartime. Rilke’s poetizing of the residents’ traces visible due to the missing façade of a condemned house has a different impact when associated with a shelled building. Perhaps home is a place where stories intertwine in ways that affect one’s quest for identity in a nuclear and explosive manner. What is an architectural home? What is home in the history and theory of architecture? Is public space the opposite of private housing? Cosmopolitanism the opposite of regionalism? Stories intersect these poles. They are both architecture’s immaterial and real side. The lecture course discusses these issues through glimpses into texts by natural-born writers like Kafka, Joyce, Munro, Didion or Danielewsky, by engineers like Musil, by musicians like Cage, by architects like Frisch and Burger, Tschumi’s detective stories encounter Koolhaas’ citationist joy in the wake of poststructuralist or deconstructionist recourses to the Freudian uncanny. |
| **Objective** | The objective of the course is to provide knowledge of literary aspects for an architectural practice committed to create spaces for living. |
| **Content** | This class studies Antiquity and the Middle Ages through their reception since the Renaissance. We will investigate the role of history for architects then and now by analyzing how architecture has been defined in relationship to the past. The course includes short critical reading and writing assignments (in coordination with studio deadlines). |
| **Literature** | Syllabus and readings on https://www.gta.arch.ethz.ch/staff/michael-gnehm/courses |

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Autumn Semester 2022
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This course offers a brief introduction to contemporary urban problems and challenges. Based on a thematic approach, the course explores

History and Theory in Architecture IX

Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

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

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

Abstract

This course aims to offer a survey of the history and current state of urban theory for students of urban design and architecture.

Objective

This is obviously not new, nor limited to the current urban condition. The discourse regarding the size and growth of cities, its functioning and politics, has a long pedigree in history, going back to the establishment of Greek and Roman city-states. This survey course aims to offer an introduction to issues at stake in cities, tailored to students of architecture and urban design. It will explore the past and current discourses, and will access a broad range of perspectives. It also does an effort to expand the scope beyond regular Western-European and North-American perspectives from Western world. The course will specifically address how architecture (positively or negatively) is involved in these issues.

Content

This course consists of weekly, one-hour lectures that address one particular topic at a time. In each lecture, this theme is investigated through different texts and case-studies that highlight crucial moments in the history and developments of cities. At the same time, the case studies will be structured so as to bridge between urban theories and concrete urban situations, design reflections and political ambitions. This will help convey to students the historical pedigree of current discourses on cities, whether simultaneously gain insight the role of designers in respect to the chosen topic. Students will prepare the meetings by reading fragments from core texts on the foreground.

The course is finalized through the writing of an essay, wherein the student is challenged to question how architectural agency can address (a) contemporary urban issue(s).

Lecture 01 – Introduction
Lecture 02 – Politics
Lecture 03 – Public Space
Lecture 04 – Capital
Lecture 05 – Climate Change
Lecture 06 – Technology
Lecture 07 – Tourism
Lecture 08 – Migration
Lecture 09 – Housing
Lecture 10 – Participation
Lecture 11 – Architectural Agency

Literature

For this course, each week students will read fragments from key readings on the topics addressed. The readings will be made available via the website of the course prior to HS2022.
Taught competencies

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

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies

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

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

063-0803-22L History and Theory in Architecture IX: Neighborhood - Towards an Exhibition

Abstract
The Swiss Pavilion with the title “Neighborhood” for the 2023 Architecture Biennale is curated by Karin Sander and Philip Ursprung. The Hawaiian Pavilion shares a wall with the neighboring pavilion of Venezuela. The lecture deals with the process of conception and realization of the exhibition.

Objective
Knowledge of contemporary discourse on architecture exhibitions.

Content
The Swiss Pavilion with the title “Neighborhood” for the 2023 Architecture Biennale is curated by Karin Sander and Philip Ursprung. The topic originates in the fact that the Swiss Pavilion, by Bruno Giacometti is sharing a wall with the neighboring pavilion of Venezuela by Carlo Scarpa. The spatial proximity of the two buildings from the 1950s raises questions about the meaning of neighborhood. The lecture deals with the process of conception and realization of the exhibition and reflects on the conditions and possibilities of architectural exhibits in general.

Field of Historic Building Research and Conservation

Number Title Type ECTS Hours Lecturers
063-0911-22L Future Monuments W 2 credits 2V S. Langenberg

Abstract
Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice.

Objective
In addition to active participation in the discussions, students will be asked to engage with a topic or object of their own choice in order to be able to develop and comprehensively justify their own positions within the context of preservation. Our goal here is to foster students’ communication skills and the culture of discussion.

Content
The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. This core conveys this knowledge to students with the help of selected writings and discusses them in the context of various guest lectures. In addition to dealing with historical buildings, the course is also dedicated to younger (and very young) objects and inventories - for in addition to the preservation of already listed objects, the selection and inventory of future protected objects is also one of the core tasks of heritage conservation.
READING LIST

Monographs and edited volumes:


Dehio, Georg, Kuhnhistorische Aufsätze. München 1914


Franz, Birgit, Gerhard Vinken und Johanna Blokker (Hg.), Denkmal-Werte - Bewertung, Denkmalpflege im Spannungsfeld von Fachinstitution und bürgerschaftlichem Engagement, Holzminden 2013 (Veröffentlichung des Arbeitskreises Theorie und Lehre der Denkmalpflege e.V., Band 23).

Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohlleben, Marion und Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:

Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008

Stadt Zürich Hochbaudepartement, Amt für Städtebau (Hg.), Bauten, Gärten und Anlagen 1960 bis 1980. Inventarergänzung, August 2013


Die Kunstdenkmäler der Schweiz

INSA – Inventare der Heimatkantonen der Teilnehmenden
Construction History: The Construction Site and Its Technology

**Abstract**

History of the construction site and its technology

**Objective**

Introduction to Construction History and the so-called "building archeology": ability to perform a "cloe reading" of historic built fabric, based on an in-depth knowledge on historic production techniques, both in the workshop and on the construction site itself.

**Content**

This lecture series deals with the history of the production of buildings. This history draws heavily on pictorial and archival sources, but the lecture will always establish the link to traces observable on site. In that sense, the lecture is an introduction to the wide topic of "building archeology". Among others, we will cover the following topics:

- construction materials, tools and tooling of construction elements
- material flow and economic boundary conditions of the construction site
- construction site technology and construction machinery (scaffolding, cranes, etc.)
- historic methods of architectural planning
- history of building production

This lecture is closely related to current research projects.

**Lecture notes**

PDFs of the lecture slides will be provided before the lecture. Furthermore, the audience will be granted access to recent journal articles and book chapters providing in-depth insight into the topics covered by the lecture.

---

Case Studies Construction History and Building Preservation

**Abstract**

Acquiring in-depth knowledge of construction history and building archeology by means of detailed study of selected historic monuments. The course will start with a multi-part classroom introduction, followed by field studies in small groups.

**Objective**

The participants will gain in-depth knowledge on the methodology of building archeology by means of the documentation and interpretation of real historic structures in on-site studies.
We study historic constructions in German-speaking Switzerland (individual small groups, objects within 2 hrs public transport reach from ETH Hoenggerberg). Each group will be assigned an individual tutor (PhD student) who will be present on-site, on individual appointment.

We will survey, document and analyze a historic construction, with particular attention to production traces, constructive detail and load-carrying system.

We will start with introductory classroom lectures and on-site teaching during the first third of the semester. This will be followed by individual investigations on site. The progress will be pinpointed in three critiques:
1) on site, with individual tutor
2) at institute, with professor and institute members
3) final delivery, at institute, with professor and all institute members

The detailed schedule of the case studies can be found here:

Each enrolment obliges the student to visit all compulsory dates during the entire semester without interruption.

Detailed instructions on on-site investigations, as well as manuscripts on the background, will be provided. It is mandatory to read them in due time!

Elementary knowledge of architectural history and construction.

Semester program:
25.9.20: On site introduction, Rümlang (Glattbrücke).
Courses in HIL E 7 until end of October.
Group work on the object or individual work (at home).

Intermediate crits and final crits at the IDB (HIT, H Level). Details will follow in due time.

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

This course conveys an introduction into methods of urban research in social sciences through lectures and accompanying exercises. It treats the basic principles of scientific research, literature research, different forms of participant observation, qualitative interviews (expert interviews and ethnographic interviews), and the analysis of urban qualities.

This course aims at enabling students of architecture to use sociological analysis as basis for concrete projects in architecture and urban design. It is based on a specific set of methods that is applied in design studios (integrated disciplines) as well as in the master thesis (supplementary discipline sociology).

This course sets up an agenda for widening the disciplinary field of architecture and urbanism from their focus on the city, or the urban in the narrow sense, to wider territorial scales, which correspond to the increasing scales of contemporary urbanisation. It discusses the concepts of territory and urbanisation, and their implications for the work of architects and urbanists.

This course will enable students to critically discuss concepts of territory and urbanisation. It will invite students to revisit the history of architects’ work engaging with the problematic of urbanising territories and territorial organisation. The goal is to motivate and equip students to engage with territory in the present day and age, by setting out our contemporary urban agenda.

The lectures are animated by a series of visual and conceptual exercises, usually on A4 sheets of paper. All original student contributions will be collected and bound together, creating a unique book-object. Some of the exercises are graded and count as proof of completion.
The course is centered around a design exercise where the form should be the result of the flow of internal forces and the detailing concept.

The demonstration of economic considerations within the design and construction process of buildings is the main focus of the diploma.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>063-0417-22L</td>
<td>Architecture and Structure</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>J. Schwartz</td>
</tr>
<tr>
<td>063-0601-22L</td>
<td>Building Process: Economy</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>H. Reichel, S. Menz</td>
</tr>
<tr>
<td>063-0605-22L</td>
<td>Computational Structural Design</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>L. Enrique Monzo, P. Block</td>
</tr>
</tbody>
</table>

Abstract

Urban physics: wind, wind comfort, pollutant dispersion, natural ventilation, driving rain, heat islands, climate change and weather conditions, urban acoustics and energy use in the urban context.

Objective

- Basic knowledge of the global climate and the local microclimate around buildings
- Impact of urban environment on wind, ventilation, rain, pollutants, acoustics and energy, and their relation to comfort, durability, air quality and energy demand
- Application of urban physics concepts in urban design

Content

- Climate Change. The Global Picture: global energy balance, global climate models, the IPCC process. Towards regional climate scenarios: role of spatial resolution, overview of approaches, hydrostatic RCMs, cloud-resolving RCMs
- Urban micro climate and comfort: urban heat island effect, wind flow and radiation in the built environment, convective heat transport modelling, heat balance and ventilation of urban spaces - impact of morphology, outdoor wind comfort, outdoor thermal comfort
- Urban energy and urban design. Energy performance of building quarters and cities, decentralized urban energy production and storage technologies, district heating networks, optimization of energy consumption at district level, effect of the micro climate, urban heat islands, and climate change on the energy performance of buildings and building blocks.
- Wind driving rain (WDR): WDR phenomena, WDR experimental and modeling, wind blocking effect, applications and moisture durability
- Pollutant dispersion, pollutant cycle: emission, transport and deposition, air quality
- Urban acoustics. noise propagation through the urban environment, meteorological effects, urban acoustic modeling, noise reduction measures, urban vegetation
- Practical exercise on climatic data collection and analyze

Lecture notes

The course lectures and material are provided online via Moodle.

Prerequisites / notice

For MIBS Master students 151-8011-ooL Building Physics Theory & Application is a pre-requisite for this course or instructor permission. For others no prior knowledge is required.

063-0417-22L

Abstract

The course is centered around a design exercise where the form should be the result of the flow of internal forces and the detailing concept combined with the quality of architectural space. The focus is on structural and load bearing issues with respect to realization implemented in an architectural design.

Objective

Understanding of structural design as translation of structural concepts into building materials with respect to design concepts.

Content

The course is centered around a design exercise where the form should be the result of the flow of internal forces and the detailing concept combined with the quality of architectural space. The focus is on structural and load bearing issues with respect to realization implemented in an architectural design.

Prerequisites / notice

ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h:
Room: HIB Open Space 2 (HIB E52) or online. Zoom link:
hhttps://ethz.zoom.us/j/6684810727

063-0601-22L

Abstract

The demonstration of economic considerations within the design and construction process of buildings is the main focus of the diploma elective subject.

Objective

To grasp the coherences of costs, income and income return.

Content

The demonstration of economic considerations within the design and construction process of buildings is the main focus of the diploma elective subject. Alongside determining basic principles, case studies play an important role in teaching. The economic factors of building construction are examined and the specific decision process is simulated. The case studies in the lectures as well as the processing of individual topics within the framework of elective work permit and require students active participation.

Lecture notes

The recordings of the lectures are available on the MAP under the link https://map.arch.ethz.ch (book symbol at the top right).

Literature

https://map.arch.ethz.ch

Prerequisites / notice

ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h:
Room: HIB Open Space 2 (HIB E52) or online. Zoom link:
hhttps://ethz.zoom.us/j/6684810727

Your presence on the first course day is obligatory!
Further information: http://www.bauprozess.arch.ethz.ch/education/MSc/BauprozessOekonomie.html

063-0605-22L

Abstract

To participate in this course it is recommended that the student has previously taken the courses Tragwerksentwurf I-IV.
Abstract

Determination of the internal forces and description of the behaviour of load-bearing structures with the help of graphic statics. Design of details and simple dimensioning of these structures. Discussion of reference structures, illustration of the interaction of the structure and the architectural design. Application of all that in an own design.

Objective

Understanding of the relationship between internal forces and the design of load-bearing systems and their connection details. Creative integration of what has been learned into an open design task.

Content

Determination of the internal forces and description of the behaviour of load-bearing structures with the help of graphic statics. Design of details and simple dimensioning of these structures. Discussion of reference structures, illustration of the interaction of the structure and the architectural design. Application of all that in an own design.

Lecture notes

on eQuilibrium
"Skript Tragwerksentwurf I/II/III/IV"
http://www.block.arch.ethz.ch/eq/course/4/?lang=en

Printed versions can be bought at the chair of Structural Design Prof. Schwartz.

"Faustformel Tragwerkentwurf"
(Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2013, ISBN: 978-3-421-03904-0)

Other Learning Material:
"Form and Forces: Designing Efficient, Expressive Structures"

"The art of structures. Introduction to the functioning of structures in architecture"

Prerequisites / notice

ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h: Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

063-0607-22L Computational Methods of Energy- and Climate Design

As of FS23, this course will be offered in spring semesters only.

Abstract

The course ‘Energy- and Climate Systems III’ introduces computational design and analysis methods and tools for climate responsive architectural design. Exercises throughout the semester allow applying new concepts learnt in exemplary architectural design tasks.

Objective

By the end of this course, students will be able to:

• compare and assess passive and active design strategies for bioclimatic buildings
• analyze environmental site characteristics for its climate and (solar) energy potentials
• apply computational simulation tools to support performance-driven designs
• translate design ideas into parametric models and into optimization problems
• synthesize learnt content of the course in exemplary architectural design tasks, serving as a basis for the students’ future design studios and projects

Content

1. Concepts of climate responsive design
2. Computational analysis methods
   - Climate and site analysis
   - Daylight, airflow and energy simulations
   - Energy supply systems optimization models (energy hub)
3. Computational methods for performance driven design
   - Parametric design
   - Sensitivity and uncertainty analysis
   - Single and multi-objective optimization
4. Exercises and walkthroughs
5. Invited expert speakers and panel discussion

Prerequisites / notice

ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h: Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

We will offer weekly 1h tutorial / practice sessions in the HIB open space to recap necessary background knowledge (simple statistics, Rhino & Gh modelling), as well as to practice tools and methods learnt in class. Dates to be announced later.

Requirements and Recommendations:

MSc Arch:
- Successfully completed the online blended learning course ‘Climate responsive architecture with Hive’ beforehand (Requirement)
- Successful participation in the course ‘Energie- und Klimasysteme I + II’ (Recommendation)

MSc MIBS / Eng:
- Successfully completed the online blended learning course ‘Climate responsive architecture with Hive’ beforehand. (Recommendation)
- Successful participation in the course ‘Building Systems’. (Recommendation)

All students need to be capable of working with ‘Rhinoceros 3D’ & ‘Grashopper’ on ‘Windows’ or willing to acquire the necessary skills before or during the course.

063-0611-22L The Digital in Architecture II

Prerequisite: Successful completion of the course “Structural Design VI” (063-0606-00L), “Design III” (052-0541/43/45) or “Das Digitale in der Architektur” (063-0610-00L).

Abstract

Subject of the course is robotic fabrication in architecture. Through exercises, basic skills such as robotic control are being taught and applied to a small design and fabrication project. The course teaches how to develop a simple fabrication and material aware digital design process linked to a robotic fabrication procedure.

Objective

Students learn to use industrial robots such as the Universal Robot URS and understand basic principles of robotic control. At the end of the course, students are able to translate simple design ideas into robotic fabrication processes, which they can run independently. Furthermore students deepen their skills in Python and Grasshopper.
Working together, we will identify and collect different case studies. You will collaborate on in-depth research through historical materials and methods (field research, archival material, secondary bibliography), and you will develop individual projects in whichever medium fits your interests and your topic (text, drawing, image, video). The outcomes will be presented together at the end of the semester, and can have different forms: essays, drawings or other visual materials, maps or guides, models, films or exhibition concepts.

The course will be organized in weekly meetings: We will begin with some introductory lectures and reading sessions, but we will mostly focus on discussing your findings and work, sharpening your tools of analysis and fostering the development of each project. Rather than individual ‘desk crits’, we will discuss each project collectively, in a round table, to enable mutual feedback and a more collective exchange of ideas. As each project develops, there will also be individual feedback sessions.

This Research Studio will teach you to be both historically and critically competent. By combining different historiographical approaches, you will develop the skills to articulate research questions, carry out appropriate primary and secondary study and you will be trained in academic research and writing.

Each participant in this Fachsemester will be asked to do Aby Warburg’s work; to find the textual sources necessary to locate meaning in architecture in various different historical periods combined with methodological ideas for how one can approach such work. Proposals are open but might include: decoding the iconography of a particular building, historically and ideologically placing the ideas of a particular architect, studying a performance and its architectural setting, explaining the significance of a building during a specific political event, or reconstructing how the ideas of a particular group or class shaped a particular building or architectural type.

The sole stipulation is that the topic period should date from before 1850.

Meaning in architecture is often a more fraught question than in painting or literature. Architecture’s non-figurative nature may not appear as easy to read as the iconography of a painting or the narrative of a novel. But buildings do mean things and this meaning is inflected through audience and time. At its creation, occupation, or even violent destruction, architecture can embody all sorts of specific identifiable meanings, for definable even antagonistic groups.

Frustrated with the purely formal approach to art while a student in Strasbourg, Aby Warburg decided instead to turn to the content of paintings, specifically two paintings by Botticelli: The Birth of Venus and Primavera. Rather than lose himself in the study of composition, Warburg walked from seminar library to seminar library to find the relevant texts that would help him understand Botticelli’s iconography; to decode the symbols and stories present on the canvas and to discover what they meant to the artist in his own time. This study of meaning in art would become the main method of research of the library which still today bears his name, and through Erwin Panofsky, Helen Rosenau and Rudolf Wittkower, Warburg’s concern for meaning was extended from painting into architecture.

Each participant in this Fachsemester will be asked to do Aby Warburg’s work; to find the textual sources necessary to locate meaning in architecture. Their research will work towards a honed essay which will carefully synthesise all their material, and which will be delivered as a lecture at the end of the course. In the first half of the course participants will be provided with presentations focused on meaning in architecture in various different historical periods combined with methodological ideas for how one can approach such work. Proposals are open but might include: decoding the iconography of a particular building, historically and ideologically placing the ideas of a particular architect, studying a performance and its architectural setting, explaining the significance of a building during a specific political event, or reconstrcuting how the ideas of a particular group or class shaped a particular building or architectural type.

The sole stipulation is that the topic period should date from before 1850.

A student can only register once for a "Fachsemester" during the Master studies!

Places for this "Fachsemester" are limited. If you are interested in taking part, please send us an email with a 300-word motivation letter including an initial topic proposal to: professur.delbeke@gta.arch.ethz.ch

If you already have a specific case study in mind, please describe what this is. If not, you can describe a general idea or area of interest, and we will help you find a more specific object of study during the course sessions.

The sole stipulation is that the topic period should date from before 1850.

The application deadline is Wednesday, September 7, 2022, 8 p.m. You will receive a message about acceptance or rejection by Thursday, September 8, 2022, 2 p.m. at the latest. Students who have been rejected are provided with an opportunity to choose a design class.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>063-0655-22L</td>
<td>Subject Semester HS22 (Fachsemester) in the Field of Technology in Architecture (ITA, Prof. Schlüter)</td>
<td>W</td>
<td>14 credits</td>
<td>29A</td>
<td>A. Schlüter</td>
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<tr>
<td></td>
<td>A student can only register once for a &quot;Fachsemester&quot; during the Master studies!</td>
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<td>The application deadline for this &quot;Fachsemester&quot; is September 7, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by September 9, 2 p.m. at the latest. Students who have</td>
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</table>
In this subject semester, we explore the topic of zero-emission building design, which integrates aspects of energy, materials, technology, human behavior, and comfort into architectural design and seeks synergetic design solutions.

Upon successful completion of the subject semester, students will be able to identify concepts and relevant design parameters for zero-emission building design and develop integrated architectural design strategies. They will know how to select and use appropriate simulation and analysis tools to quantify and qualify their design solutions and will be able to visualize their concepts with both technical schematics and architectural drawings and visualizations.

The subject semester kicks off with an introduction to the use and exploitation of building systems for the design of zero-emission buildings. The goal of the semester is to demonstrate the relationships between building systems and architecture and to find ways to manifest building systems in design.

Students begin with a research and mapping phase in which they first investigate various building systems for zero-emission building design. They then map the building systems with architectural parameters for successful interaction between the two and create a catalog of their findings.

After the research and mapping phase, students design a small building in which they explore how to maximize the interactions between the building systems and the architectural parameters. Finally, students attempt to quantify their design solutions using low-threshold modeling, simulation, and optimization tools such as Rhino/Grasshopper or HIVE. To assess and discuss their concepts not only numerically but also architecturally and aesthetically, students also find appropriate forms of visualization.

Students document the process and results both numerically and architecturally, which are then discussed with a final jury.

The working mode is an individual design research studio with weekly group meetings and reviews. We expect good basic knowledge of sustainable construction and energy and climate systems. Prior experience in parametric design tools (e.g. Rhino) and/or simulation tools is a plus.

Please note that a student can only register once for a subject semester during the master's program!

Apply with a brief letter of motivation by 8 pm on September 7, 2022 to: illias.hischier@arch.ethz.ch. Your participation in the subject semester will be confirmed by September 9, 2022.

The subject semester (to choose out of two topics) includes the individual, independent processing of a specific task, whereby the relevance of the respective discipline is examined with regard to the specific architectural and design aspects of the task.

The subject semester includes the individual, independent processing of a specific task, whereby the relevance of the respective discipline is examined with regard to the specific architectural and design aspects of the task.

The subject of the semester is defined by the chair and published on the website:
https://holzer.arch.ethz.ch/en/education/Fachsemester.html

The requirements for this subject semester are interest in the material as well as experience with and knowledge of historical wooden structures and the methods of building research.

Ideally, the student has heard Prof. Holzer's lectures on construction history or does so during the semester. It is also beneficial to have attended the case studies exercise.
### Taught Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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063-0857-22L  **Subject Semester HS22 (Fachsemester) in the Field of History and Theory in Architecture (Avermaete)**  

**W 14 credits  29A  T. Avermaete**

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Zürich’s Land Commons</th>
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<tbody>
<tr>
<td>This Research Studio focuses on the land commons of Zürich and explores how the ways in which land is managed and appropriated influences the construction of the city. What are land commons and how do architects and other citizens engage with them? How do they help us in addressing the social, political, and environmental challenges of our time?</td>
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</table>

<table>
<thead>
<tr>
<th>Objective</th>
<th>The Research Studio has two main objectives:</th>
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<tbody>
<tr>
<td>First, to develop an ‘Archeology’ of Zürich’s land commons. In this part, the work of the urban historian or theoretician is understood as an archaeological venture. The collective stock of Zürich’s variegated land use, as well as the crafts and realizations (buildings and neighborhoods) related to it, will be systematically analyzed as the outcome of codes and as reliant on established practices of ‘commoning’. The result will be a catalogue of the city’s common-pool land resources, illustrating how these provide a basis for practices of ‘commoning’ and how, as architectural, and urban figures, they are integrated into and have an impact upon the city fabric.</td>
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<tr>
<td>Second, to identify a ‘Project for the City’. Based on the archeology, we will explore the inherent logics of the land commons of Zürich. The idea is that the uncovering of these logics not only helps to comprehend the historical development of the land commons, but also to speculate about future scenarios for engaging with the scarce land resources in the city. The past, present, and future roles of the land commons in the city will be discussed, as a more comprehensive project for the city as we know it and as it might evolve.</td>
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<tr>
<th>Content</th>
<th>Cities have always been places based on common resources. While designing and constructing the architecture of the city, architects, urban designers, builders, and inhabitants have had to engage with common resources located in particular places and geographies; inherited common-pool resources (water, nature, air); material common-pool resources (clay, brick, stone, wood); as well as immaterial common-pool resources (craft, knowledge).</th>
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<tbody>
<tr>
<td>This understanding of the city, as being intrinsically related to common resources has gained renewed attention, as neoliberalism replaces ever-shrinking welfare structures, and global urbanization is accompanied by rising inequality. It is not only architects and urban designers who are again becoming interested in alternative principles of governing common resources, but also political movements and society at large. Hence, some of these issues – generally labeled ‘the commons’ – have received growing attention in the last decades within the fields of critical urban studies, urban history, urban geography and the social sciences.</td>
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<tr>
<td>After four semesters focusing on the water commons, the green commons, the housing commons, and the material commons, this Research Studio continues the investigations into the rich history of ‘the commons’ in the city of Zürich by focusing on its land resources. The ‘land commons’ will be investigated from architectural, urban, typological, environmental, and material perspectives. We will explore how common practices have affected the development of the city, and conversely how land commons enable and structure common practices. Ultimately, this historical research will unlock an alternative reading of the urban and architectural qualities of the built environment of the city, potentially pointing to more socially inclusive and environmentally conscious alternatives to the mostly market driven land use of the city.</td>
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</table>
The main hypothesis of the Research Studio is that historical and theoretical research can gain from a profound use of the tools and knowledge of an architect. During the Research Studio students will employ specific architectural tools, such as drawing, writing, and model making to explore historical and theoretical realities. Students will be urged to explore various methods of composing analytical and interpretative drawings. They will reflect upon the capacity of drawing methods from the field of architecture, such as plan drawing, sectional drawings, mappings, serial visions, public drawings, diagramming and perspective representations to act as tools of historical and theoretical research. At the same time, they will be asked to investigate various analytical and interpretative modes of scale-model making. Students may work with different types of models (structural models, mass models, counter form models, landscape and territorial models) as ways to historically or theoretically explore the reality of the city.

Far from being simple graphic or artefactual restitutions of the city, these drawings and models will create morphological, thematic or theoretical links between various occurrences in the city. These methods of drawing and model making will be combined with more conventional investigative techniques in the fields of history and theory such as discourse analysis, iconographic studies and compositional investigation, to support a better historical or theoretical understanding of specific occurrences and conditions in the city of Zürich.

Students will also be stimulated to use their spatial, formal, material and constructive architectural knowledge to offer alternative historical or theoretical interpretations of the reality that they encounter in the archives, in the library or in the city. They will be asked to activate their specific spatial, typological, compositional, technical, material and constructive expertise to probe into the various historical layers of the architecture of the city in newfangled ways.

Within the general theme of land commons, students will be guided to identify their own subtheme, as well as explore their own different methodologies of doing research. During the Research Studio students will confront their empirical knowledge (about space, typology, composition, technique, material and construction), pertaining to the autonomy of architecture, with other types of knowledge (on politics, economy, the social and cultural) that belong to the heteronomy of architecture. In the relation between autonomous and heteronomous knowledge, a new understanding of the city will be constructed. The combination of these tools and methods will offer an in-depth mode of historical and theoretical research, wherein the students will retroactively explore the spatial, formal, material and constructive features of a particular situation to uncover and reconstruct the logics that have led to a certain urban condition. On the basis of this research, students will be able to develop an architectural hypothesis of the developments in the city of Zürich.

The studio is self-dependent work and tutoring takes place on Tuesdays and Wednesdays.

Enrollment will not take place through the D-ARCH website. To enroll for this Fachsemester please send an e-mail to sanna.kattenbeck@hta.arch.ethz.ch by Wednesday 7th September, 2022, 8 p.m. Available places will be allocated first according to the A-B-C-studio priority system, and secondly, if necessary, randomly. You will receive a confirmation by Thursday 8th September 2022, 2 p.m. In case of over-applications, students who are not selected will have the opportunity to choose a regular design studio through the D-ARCH website.

The studio website (https://avermaete.arch.ethz.ch/researchstudio) will be made available during the course’s first week.

A student can only register once for a “Fachsemester” during the Master studies!

# Focus Work

Realization in the respective fields of the institutes. Definition of topics by professors, in consultation with the students. The content may also refer to an elective course.

The performance assessment comprises either a purely written examination followed by an oral examination or a creative, manual or drawing work, including a description, followed by an oral examination. At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and knowledge gained.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

# Field of Historic Building Research and Conservation

Definition of topics by professors, in consultation with the students (student’s proposal / content of an elective course).

Performance assessment: Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination. At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

Information on exams and grades: Art. 29 of the MSc D-ARCH regulations.
In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the Study Director. The subjects can be proposed by the students. In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

### Field of Design and Architecture

**Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).**

**Abstract**

Analysis of a single monument or a small group of interrelated monuments with the methods of archeological building research. Embedding the objects studied into a context of construction history by means of archival and literature studies.

**Objective**

In-depth knowledge of the methods of archeological building research and construction history. Case-oriented in-depth knowledge of a selected historic building or construction type in its technical, social and economic setting and its architectural relevance.

**Content**

This study will require the in-depth analysis of a historic structure or a small group of structures. This includes an object documentation (survey drawings, photographic record, textual description). Contextual information to be researched by the methods of construction history (archival, literature).

**Prerequisites / notice**

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

**Information on exams and grades:** Art. 29 of the MSc D-ARCH regulations.

### Focus Work HS22 in the Field of Design and Architecture (IEA)

**Number** 063-0551-22L

**Title** Focus Work HS22 in the Field of Design and Architecture (IEA)

**Type** W

**ECTS** 6 credits

**Hours** 13A

**Lecturers** Supervisors

**Abstract**

IEA focus work, of which the content may also refer to an elective subject.

**Objective**

Development of skills and competences in a special area / sub-area of architectural theory or practice.

**Content**

In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

**Information on exams and grades:** Art. 29 of the MSc D-ARCH regulations.

### Focus Work HS22 in the Field of Design and Architecture (gta)

**Number** 063-0551-22L

**Title** Focus Work HS22 in the Field of Design and Architecture (gta)

**Type** W

**ECTS** 6 credits

**Hours** 13A

**Lecturers** Supervisors

**Abstract**

Indentation work of the Institute gta, of which the content can also refer to an elective subject.

**Objective**

Development of skills and competences in a special area / sub-area of architectural theory or practice.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

**Information on exams and grades:** Art. 29 of the MSc D-ARCH regulations.

### Field of History and Theory of Architecture

**Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).**

**Abstract**

Indentation work of the Institute gta, of which the content can also refer to an elective subject.

**Objective**

Development of skills and competences in a special area / sub-area of architectural theory or practice.

**Content**

The objects studied into a context of construction history by means of archival and literature studies.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

**Information on exams and grades:** Art. 29 of the MSc D-ARCH regulations.
Content

In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4. It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term "dropout".

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

The students can be proposed by the students. In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

Prerequisites / notice

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

Field of Landscape Architecture and Urban Studies

Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).

Performance assessment: Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

Information on exams and grades: Art. 29 of the MSc D-ARCH regulations.

Number Title Type ECTS Hours Lecturers

103-0569-00L European Aspects of Spatial Development W 3 credits 2G A. Peric Momcilovic

Abstract

Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective

Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:

- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making
- European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system; EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

Lecture notes

The documents for the lecture will be provided at the moodle.
Obligatory literature:

Recommended literature:
Governance models:

Planning models:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

Planning systems in Europe:

Prerequisites / notice
Only for master students, otherwise a special permission by the lecturer is required.

Taught competencies

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

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

Social Competencies

| Communication                | assessed               |         |
| Cooperation and Teamwork    | assessed               |         |
| Self-presentation and Social Influence | assessed |         |
| Sensitivity to Diversity    | assessed               |         |
| Negotiation                 | assessed               |         |

Personal Competencies

| Adaptability and Flexibility | assessed               |         |
| Creative Thinking           | assessed               |         |
| Critical Thinking           | assessed               |         |
| Integrity and Work Ethics   | assessed               |         |
| Self-awareness and Self-reflection | assessed |         |
| Self-direction and Self-management | assessed |         |

Abstract
Indentation work of the Institute LUS, of which the content can also refer to an elective subject. The topic is determined in consultation with the chosen professor.

Objective
Development of skills and competences in a special area / sub-area of architectural theory or practice.
Content

In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4.

It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term “dropout”.

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The subjects can be proposed by the students.

In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

Taking place from 10.-28.1.22 in ONA G25.

Field of Technology in Architecture

Definition of topics by professors, in consultation with the students (student’s proposal / content of an elective course).

Prerequisites / notice

Performance assessment: Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

Information on exams and grades: Art. 29 of the MSc D-ARCH regulations.

Number Title Type ECTS Hours Lecturers
063-0651-22L Focus Work HS22 in the Field of Technology in Architecture (ITA) W 6 credits 13A Supervisors

Abstract

Indentation work of the Institute ITA of which the content can also refer to an elective subject.

The topic is determined in consultation with the chosen professor.

Objective

Development of skills and competences in a special area / sub-area of architectural theory or practice.

Content

In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth study can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4.

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An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The subjects can be proposed by the students.

In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

Master’s Thesis

Only students who fulfill the following criteria are allowed to begin with their master thesis:

Number Title Type ECTS Hours Lecturers
063-0141-00L Master’s Thesis O 30 credits 40D Lecturers
a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Ultimate deadline to unsubscribe or enroll for the Master Thesis is 16.11.22.
Deleting a reservation after this date is prohibited.

Abstract
The master's thesis is the completion of the Master's degree.

Objective
It shows the students' ability to work independently and is a proof of the successful completion of their studies.

Prerequisites / notice
The Master's thesis is supervised by a design professor D-ARCH. The students can choose one of the topics presented by the D-ARCH or - after approval by the head of the work - a free, self-chosen topic. Further details are regulated in Articles 31-38.

Electives
see "electives" in Architecture BSc

Seminar Weeks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>051-0911-Z2L</td>
<td>Seminar Week Autumn Semester 2022</td>
<td>W</td>
<td>2 credits</td>
<td>3A</td>
<td>Lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>The seminar week is obligatory for students of all semesters. There are many and varied study contents.</td>
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<tr>
<td>Objective</td>
<td>The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.</td>
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</tbody>
</table>

Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability
Recommended Science in Perspective (Type B) for D-ARCH
see Science in Perspective: Language Courses ETH/UZH

Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-1100-AAL</td>
<td>Architectural Design V-IX (Part 1)</td>
<td>E-</td>
<td>14 credits</td>
<td>16U</td>
<td>Lecturers</td>
</tr>
<tr>
<td>Enrolment</td>
<td>Only for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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</tr>
<tr>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td>Please register (<a href="http://www.mystudies.ethz.ch">www.mystudies.ethz.ch</a>) only after the internal enrolment for the design classes (see <a href="http://www.einschreibung.arch.ethz.ch/design.php">http://www.einschreibung.arch.ethz.ch/design.php</a>)</td>
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<tr>
<td>Project grading at semester end is based on the list of enrolments on 1.11.2022 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.</td>
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<tr>
<td>Abstract</td>
<td>Session requirements.</td>
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<tr>
<td>Objective</td>
<td>Requirements.</td>
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<tr>
<td>Content</td>
<td>Session requirements.</td>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-1101-AAL</td>
<td>Architectural Design V-IX (Part 2)</td>
<td>E-</td>
<td>14 credits</td>
<td>16U</td>
<td>Lecturers</td>
</tr>
<tr>
<td>Enrolment</td>
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<tr>
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<tr>
<td>Abstract</td>
<td>Session requirements.</td>
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<td>Content</td>
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</table>

Architecture Master - Key for Type

| O          | Compulsory | E-  | Recommended, not eligible for credits |
| W+         | Eligible for credits and recommended      | Z   | Courses outside the curriculum       |
| W          | Eligible for credits                      | Dr  | Suitable for doctorate               |
### Key for Hours

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

**ECTS** | European Credit Transfer and Accumulation System  
- Special students and auditors need special permission from the lecturers.
Boundary Layer Meteorology

- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Prerequisites / notice

Physics I, II, Environmental Fluid Dynamics

Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes

Dynamics of large-scale atmospheric flow

Literature

- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Prerequisites / notice

Physics I, II, Environmental Fluid Dynamics

Climate Processes and Feedbacks

Cloud Microphysics


Prerequisites / notice

Target group: Doctoral and Master students in Atmosphere and Climate
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

Objective
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Powerpoint slides will be made available

Prerequisites / notice
Prerequisites: Introductory lectures in atmospheric and climate science
and/or

Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

Objective
Physical and chemical principles:
The students...
- know the processes and physical laws of aerosol dynamics.
- understand the thermodynamics of phase equilibria and chemical equilibria.
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:
The students...
- know the most important chemical and physical measurement instruments.
- understand the underlying chemistry and physics.

Environmental impacts:
The students...
- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- know the most important climate impacts of atmospheric aerosols.

are aware of the health impacts of atmospheric aerosols.

Lecture notes
Material is distributed during the lecture

Literature

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed

Method-specific Competencies
Project Management not assessed

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

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

701-1233-00L Stratospheric Chemistry W 4 credits 2V+1U T. Peter, G. Chiodo

Autumn Semester 2022
The lecture gives an overview on the manifold reactions which occur in the gas phase, in stratospheric aerosol droplets and in polar cloud particles. The focus is on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.

The students will understand the gas phase reactions in the stratosphere as well as reactions and processes in aerosol droplets and polar stratospheric clouds.

The students will understand the most important aspects of stratospheric dynamics and the greenhouse gas effect in troposphere and stratosphere.

The students will also acquire a good understanding of the coupling between stratospheric ozone and climate change.

Furthermore, they will practice to explain fundamental concepts in stratospheric chemistry by means of scientific paper presentations.

Short presentation of thermodynamical and kinetic basis of chemical reactions: bi- and termolecular reactions, photo-dissociation, introduction to the chemical family concept: active species, their source gases and reservoir gases. Detailed treatment of the pure oxygen family (odd oxygen) according to the Chapman chemistry. Radical reactions of the oxygen species with nitric oxide, active halogens (chlorine and bromine) and odd hydrogen. Ozone depletion cycles. Methane depletion and ozone production in the lower stratosphere (photo-smog reactions). Heterogeneous chemistry on the background aerosol and its significance for heavy air traffic. Chemistry and dynamics of the ozone hole: Formation of polar stratospheric clouds and chlorine activation.

The lecture notes are provided in the contact hours.

Documents are available online: [link to lecture notes].


Prerequisites / notice

Basics in physical chemistry are required and an overview equivalent to the bachelor course in atmospheric chemistry (lecture 701-0471-01) is expected.

701-1233-00 V starts in the first week of the semester. The exercises 701-1233-00 U will start only in the 2nd week of the semester.

### Climate History and Palaeoclimatology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>651-4057-00L</td>
<td>Climate History and Palaeoclimatology</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>H. Stoll, I. Hernández Almeida, H. Zhang</td>
</tr>
</tbody>
</table>

#### Abstract

Climate history and palaeoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

#### Objective

The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

#### Content

The course spans 5 thematic modules:

1. **Cyclic variation in the earth's orbit and the rise and demise of ice sheets.** Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?
2. **Feedbacks on climate cycles from CO2 and methane.** What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?
3. **Atmospheric circulation and variations in the earth's hydrological cycle.** How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?
4. **Century-scale droughts and civil catastrophes.** Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?
5. **How sensitive is Earth's long term climate to CO2 and cloud feedbacks?** What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new palaeoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### Hydrology and Water Cycle

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<tr>
<th>Number</th>
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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>701-1251-00L</td>
<td>Land-Climate Dynamics</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>S. I. Seneviratne, R. Padrón Flasher, P. Sieber</td>
</tr>
</tbody>
</table>

The target groups are the following:
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.

#### Abstract

The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

#### Objective

The students can understand the role of land processes and associated feedbacks in the climate system.

#### Lecture notes

Powerpoint slides will be made available.

#### Prerequisites / notice

Prerequisites: Introductory lectures in atmospheric and climate science

Atmospheric physics -> [link to course page].

Climate systems -> [link to course page].
Analysis of Climate and Weather Data

W 3 credits 2G  C. Frei

Abstract
An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.

Objective
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.

Content
The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

Lecture notes
Documentation and supporting material:
- Exercise sets and solutions
- R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

Literature
For complementary reading:

Prerequisites / notice
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften (701-0105-00L)), Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

Boundary Layer Meteorology

W 4 credits 3G  M. Rotach, P. Calanca

Abstract
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective
Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example for complex topography).

Content
- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes
available (i.e. in English)

Literature

Prerequisites / notice
Umwelt-Fluideynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Watershed Modelling

W 6 credits 4G  P. Molnar

Abstract
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercice hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

Content
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
Literature consists of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).
The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:

• observational datasets, observation and detection of climate change;
• underlying physical processes and feedbacks;
• numerical and statistical approaches;
• currently available projections.

Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:

• observational datasets, observation and detection of climate change;
• underlying physical processes and feedbacks;
• numerical and statistical approaches;
• currently available projections.

Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge.
Objective

At the end of this course, participants should:
• understand the key physical processes shaping climate change in Europe;
• know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
• be familiar with relevant observational and modeling data sets;
• be able to tackle simple climate change questions using available data sets.

Content

Contents:
• global context
• observational data sets, analysis of climate trends and climate variability in Europe
• global and regional climate modeling
• statistical downscaling
• key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
• projections of European and Alpine climate change

Lecture notes

Slides and lecture notes will be made available at http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html

Prerequisites / notice

Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

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Atmospheric Composition and Cycles

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<tr>
<th>Number</th>
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<tr>
<td>102-0635-01L</td>
<td>Air Pollution Control</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>J. Wang, B. Buchmann</td>
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</table>

Abstract

The lecture provides in the first part an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and their impact on air quality. The second part covers different strategies and techniques for emission reduction. The basic knowledge is deepened by the discussion of specific air pollution problems of today’s society.

Objective

The students gain general knowledge of the technical processes resulting in air pollution and study the methods used for air pollution control. The students can identify major air pollution sources and understand the methods for measuring pollutants, collecting and analyzing data. The students can suggest and evaluate possible control methods and equipment, design control systems and estimate their efficiency and efforts.

The students know the different strategies of air pollution control and are familiar with their scientific fundamentals. They are able to incorporate goals concerning air quality into their engineering work.

Content

Part 1 Emission, Immission, Transmission

Fluxes of pollutants and their environmental impact:
- physical and chemical processes leading to emission of pollutants
- mass and energy of processes
- Emission measurement techniques and concepts
- quantification of emissions from individual and aggregated sources
- extent and development of the emissions (Switzerland and global)
- propagation and transport of pollutants (transmission)
- meteorological parameters influencing air pollution dispersion
- deterministic and stochastic models, describing air pollution dispersion
- dispersion models (Gaussian model, box model, receptor model)
- measurement concepts for ambient air (immission level)
- extent and development of ambient air mixing ratios
- goal and instrument of air pollution control

Part 2 Air Pollution Control Technologies

The reduction of the formation of pollutants is done by modifying the processes (process-integrated measures) and by different engineering operations for the cleaning of waste gas (downstream pollution control). It will be demonstrated, that the variety of these procedures can be traced back to the application of a few basic physical and chemical principles.

Procedures for the removal of particles (inertial separator, filtration, electrostatic precipitators, scrubbers) with their different mechanisms (field forces, impaction and diffusion processes) and the modelling of these mechanisms.

Procedures for the removal of gaseous pollutants and the description of the driving forces involved, as well as the equilibrium and the kinetics of the relevant processes (absorption, adsorption as well as thermal, catalytic and biological conversions).

Discussion of the technical possibilities to solve the actual air pollution problems.

Lecture notes

Brigitte Buchmann, Air pollution control, Part I
Jing Wang, Air pollution control, Part II
Lecture slides and exercises

Literature

List of literature included in script

Prerequisites / notice

College lectures on basic physics, chemistry and mathematics.

Language of instruction: In German or in English.
Taught competencies | Subject-specific Competencies | Concept and Theories | assessed
---|---|---|---
Method-specific Competencies | Analytical Competencies | assessed
Decision-making | assessed
Media and Digital Technologies | not assessed
Problem-solving | assessed
Project Management | not assessed
Social Competencies | Communication | assessed
Cooperation and Teamwork | not assessed
Customer Orientation | not assessed
Leadership and Responsibility | not assessed
Self-presentation and Social Influence | not assessed
Sensitivity to Diversity | not assessed
Negotiation | not assessed
Personal Competencies | Adaptability and Flexibility | assessed
Creative Thinking | assessed
Critical Thinking | assessed
Integrity and Work Ethics | assessed
Self-awareness and Self-reflection | not assessed
Self-direction and Self-management | not assessed

701-1235-00L Cloud Microphysics W 4 credits 2V+1U Z. A. Kanji, N. Shardt, Y. Wang

Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes. All participants will be on the waiting list at first. Enrollment is possible until 14.09.2022. The waiting list is active until 30.09.2022. All students will be informed on 15./16.09.2022, if they can participate in the lecture. Priority is given to PhD students majoring in Atmospheric and Climate Sciences, and remaining open spaces will be offered to the following groups:
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

This course will be designed as a reading course in 1-2 small groups of 10 students maximum. It will be based on the textbook below. The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth.

Literature
Lamb and Verlinde: PHYSICS AND CHEMISTRY OF CLOUDS, Cambridge University Press, 2011

Prerequisites / notice
Target group: Doctoral and Master students in Atmosphere and Climate

651-4053-05L Boundary Layer Meteorology W 4 credits 3G M. Rotach, P. Calanca

The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

Content
- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes
available (i.e. in English)

Literature

Prerequisites / notice
Umwelt-Fluidynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 132 of 2345
## Sedimentology I: Physical Processes and Sedimentary Systems

**Number**: 651-4041-00L  
**Title**: Sedimentology I: Physical Processes and Sedimentary Systems  
**Type**: W  
**ECTS**: 3 credits  
**Hours**: 2G  
**Lecturers**: V. Picotti  

**Abstract**: Sediments preserved a record of past landscapes. This course focuses on understanding the processes that modify sedimentary landscapes with time and how we can read this changes in the sedimentary record.  

**Objective**: The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.  

**Content**: Details on the program will be handed out during the first lecture.  

**Literature**: The sedimentary record of sea-level change  
Angela Coe, The Open University.  
Cambridge University Press  

**Prerequisites / notice**: The grading of students is based on in-class exercises and end-semester examination.  

## Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems

**Number**: 651-4043-00L  
**Title**: Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems  
**Prerequisite**: Successful completion of the MSc-course "Sedimentology I" (651-4041-00L)  

**Abstract**: The focus will be on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Nurtic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.  

**Objective**:  
- You will understand chemistry and biology of the marine carbonate system  
- You will be able to relate carbonate mineralogy with facies and environmental conditions  
- You will be familiar with cool-water and warm-water carbonates  
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle  
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)  
- You will be able to use geological archives as source of information on global change  
- You will have an overview of marine sedimentation through time  

**Content**:  
- carbonates,.; chemistry, mineralogy, biology  
- carbonate sedimentation from the shell to the deep sea  
- carbonate facies  
- cool-water and warm-water carbonates  
- organic-carbon and black shales  
- C-cycle, carbonates, Org : CC2 sources and sink  
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr  
- marine sediments through geological time  
- carbonates and evaporites  
- lacustrine carbonates  
- economic aspects of limestone  

**Lecture notes**: no script. scientific articles will be distributed during the course  

**Literature**: We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"  

**Prerequisites / notice**: The grading of students is based on in-class exercises and end-semester examination.  

## Quaternary Dating Methods

**Number**: 651-4901-00L  
**Title**: Quaternary Dating Methods  
**Type**: W  
**ECTS**: 3 credits  
**Hours**: 2G  
**Lecturers**: I. Hajdas, M. Christl, S. Ivy Ochs  

**Abstract**: Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.  

**Objective**: Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.  

At the end of the course students will:  
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.  
2. be able to calculate an age based on data of the six methods studied.  
3. choose which dating method (or combination of methods) is suitable for a certain field problem.  
4. critically read and evaluate the application of dating methods in scientific publications.  

**Content**:  
1. Introduction: Time scales for the Quaternary, Isotopes and decay  
2. Radiocarbon dating: principles and applications  
3. Cosmogenic nuclides: 3He,10Be, 14C, 21Ne, 26Cl, 36Cl  
4. U-series disequilibrium dating  
5. Luminescence dating  
6. Introduction to incremental: varve counting, dendrochronology and ice cores chronologies  
7. Cs-137 and Pb-210 (soil, sediments, ice core)  
8. Summary and comparison of results from several dating methods at specific sites  

**Prerequisites / notice**: Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.  

**Visit to Limno Lab and sampling a sediment core**: Optional (individual): 1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggereg  

**Required**: attending the lecture, visiting laboratories, handing back solutions for problem sets (Exercises)  

## Hydrology and Water Cycle

**Number**: 651-4023-00L  
**Title**: Groundwater  
**Type**: W  
**ECTS**: 4 credits  
**Hours**: 4G  
**Lecturers**: X.-Z. Kong, B. Marti  

**Abstract**: The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, formulating, and solving groundwater flow and solute transport problems.  

**Objective**:  
- Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions.  
- Students are able to formulate simple, practical groundwater flow and solute transport problems.  
- Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems.  

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Autumn Semester 2022  
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Content
1. Introduction to groundwater problems. Concepts to quantify properties of aquifers.
2. Flow equation. The generalised Darcy law.
3. The water balance equation and basic concepts of poroelasticity.
5. Analytical solutions to flow problems
6. Finite difference scheme solution for simple flow problems.
10. Analytical solutions to transport problems.
11. Fractured and karst aquifers.
12. The unsaturated zone and capillary pressure.
13. Examples of applied hydrogeology from Switzerland and around the world. (Given by Dr. Beatrice Marti from Hydrosolutions Ltd.)

Lecture notes
Handouts of slides.

Literature
de Marsily G., Quantitative Hydrogeology, Academic Press, 1986

River Basin Erosion
W 3 credits 2G P. Molnar

Abstract
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Objective
The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

Content
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes
There is no script.

Literature
The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice
Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

Environmental Soil Physics/Vadose Zone Hydrology
W 3 credits 2V+1U A. Carminati, P. U. Lehmann Grunder

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

Objective
Students are able to
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils
Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid, liquid and gaseous phases; soil water content; soil texture; particle size distributions;

Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure

Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab

Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, and capillary rise); units and calculations and measurement of equilibrium soil water potential components

Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab

Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)

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

Week 8: Numerical solution of Richards equation – using Hydrus1D for simulation of unsaturated flow; choosing class project

Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow

Week 10: Root water uptake and transpiration

Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 12: Summary of lectures; solution of old exam

Week 13: Written semester-end exam

Week 14: Short presentations of Hydrus class projects; discussion of written exam

Content

The course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Knowledge and skills

(1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Prerequisites

Students are also welcome. PhD students please register via the study administration.

Literature

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

651-2915-00L Seminar in Hydrology Z 0 credits 1S P. Burlando, J. W. Kirchner, C. Schär, M. Schirmer, S. I. Seneviratne, M. Stähli, C. H. Stamm, University lecturers

860-0012-00L Cooperation and Conflict Over International Water Resources W 3 credits 2G T. Bernauer, T. U. Siegfried

Number of participants limited to 40.

Priority for Science, Technology, and Policy MSc.

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

Abstract

This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Objective

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

20.Sep Global water challenges
27.Sep Nuts and bolts of hydrological modeling and what such models can tell us
04.Oct Nuts and bolts of hydrological modeling and what such models can tell us
11.Oct Water pollution and its mitigation
18.Oct Key challenges in international river systems
25.Oct Key challenges in international river systems
01.Nov Case study 1: Yarmuk
08.Nov Case study 2: Mekong
15.Nov Case study 3: Colorado
22.Nov Case study 4: Nile
29.Nov Case study 5: Central Asia
06.Dec Wrap up: what we can learn from these case studies
13.Dec Exam
20.Dec No class

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Lecture notes

Slides and reading materials will be made available via Moodle.

Literature

Slides and reading materials will be made available via Moodle.

Prerequisites / notice

The course is open to Master and doctoral students from any area of ETH.

Limited to 40 students.

Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.
### Prerequisites

The definition of prerequisites is part of the admission procedure for the master studies. You are informed by the admission office as to what courses of the section «prerequisites» you have to catch up with. You are accredited for these courses in the electives block of the master studies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0471-01L</td>
<td>Atmospheric Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Ammann, T. Peter</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td></td>
<td>This self-study course provides an introduction to atmospheric chemistry at bachelor level. It introduces the fundamentals of gas phase reactions, the concept of solubility and reactions in aerosols and in clouds. It explains the chemical and physical processes responsible for global (e.g. stratospheric ozone depletion) as well as regional environmental problems (e.g. urban air pollution). The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere. The students will also acquire a good understanding of atmospheric environmental problems including air pollution, tropospheric ozone formation, stratospheric ozone destruction and the relationship between air pollution and climate change.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere. The students will also acquire a good understanding of atmospheric environmental problems including air pollution, tropospheric ozone formation, stratospheric ozone destruction and the relationship between air pollution and climate change.</td>
</tr>
<tr>
<td>Literature</td>
<td>Lecture notes / notice</td>
<td></td>
<td></td>
<td></td>
<td>Lecture materials (slides and annotations) of the most recent corresponding bachelor course are provided. Basic courses in chemistry and physics are expected</td>
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<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>701-0473-00L</td>
<td>Weather Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. A. Sprenger, F. Scholder- Aemisegger</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes The students are able to - explain basic measurement and analysis techniques that are relevant in atmospheric dynamics - to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena - to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features - to explain how mountains influence the global atmosphere on different scales - to understand the phases of severe convective storms. Students also learn to classify radiosondes with the help of thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection. Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed. With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms. The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere. The students will also acquire a good understanding of atmospheric environmental problems including air pollution, tropospheric ozone formation, stratospheric ozone destruction and the relationship between air pollution and climate change.</td>
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<td>Objective</td>
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<td></td>
<td>The students are able to - explain basic measurement and analysis techniques that are relevant in atmospheric dynamics - to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena - to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features - to explain how mountains influence the global atmosphere on different scales - to understand the phases of severe convective storms. Students also learn to classify radiosondes with the help of thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection. Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed. With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms. The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere. The students will also acquire a good understanding of atmospheric environmental problems including air pollution, tropospheric ozone formation, stratospheric ozone destruction and the relationship between air pollution and climate change.</td>
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<tr>
<td></td>
<td>Content</td>
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<td></td>
<td>Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes</td>
</tr>
<tr>
<td>Literature</td>
<td>Lecture notes / notice</td>
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<td></td>
<td>Lecture notes and slides</td>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0475-00L</td>
<td>Atmospheric Physics</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>F. Mahrt</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification. Students are able - to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics. - to evaluate the significance of clouds and aerosol particles for artificial weather modification. n the course &quot;Atmospheric Physics&quot;, the competencies of process understanding, system understanding and data analysis &amp; interpretation are taught, acquired and examined. The competence measurement methods is taught as well. The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds. The students also learn to classify radiosondes with the help of thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection. Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed. With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms. The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas. Powerpoint slides and chapters from the textbook will be made available on moodle: <a href="https://moodle-app2.let.ethz.ch/course/view.php?id=15367">https://moodle-app2.let.ethz.ch/course/view.php?id=15367</a> Literature Lohmann, U., Lübä, F. and Mahrt, F., An Introduction to Clouds: From the Microscale to Climate, Cambridge Univ. Press, 391 pp., 2016. Prerequisites / notice For certain capers we'll use the concept of &quot;flipped classroom&quot; (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning. We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments. There is an additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.</td>
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</table>
701-0461-00L Numerical Methods in Environmental Physics

Abstract
This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.

Objective
Ability to develop simple numerical schemes and to implement these schemes using the programming language Python. Ability to critically use more complex numerical models.

Content
Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration schemes, non-linearity, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-section of Environmental Science.

Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not necessary, a Python introduction is provided). Example programs and graphics tools are supplied.

Lecture notes

Literature
List of literature is provided.

Additional Electives ETH

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4273-00L</td>
<td>Numerical Modelling in Fortran</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Tackley</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.</td>
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<tr>
<td>Objective</td>
<td>Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.</td>
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<tr>
<td>Lecture notes</td>
<td>See <a href="http://jupiter.ethz.ch/~pjt/FORTRAN/FortranClass.html">http://jupiter.ethz.ch/~pjt/FORTRAN/FortranClass.html</a></td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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</table>

| 701-1257-00L | European Climate Change                   | W    | 3    | 2G    | C. Schär, J. Rajczak, S. C. Scherrer |
| Abstract     | The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics: observational datasets, observation and detection of climate change; underlying physical processes and feedbacks; numerical and statistical approaches; currently available projections. |
| Objective    | At the end of this course, participants should: understand the key physical processes shaping climate change in Europe; know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches; be familiar with relevant observational and modeling data sets; be able to tackle simple climate change questions using available data sets. |
| Content      | Contents: global context; observational data sets, analysis of climate trends and climate variability in Europe; global and regional climate modeling; statistical downscaling; key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects; projections of European and Alpine climate change. |
| Lecture notes | Slides and lecture notes will be made available at http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html |
| Prerequisites / notice | Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology. |

| 701-1281-00L | Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS) | W    | 3    | 6A    | Supervisors |
| Abstract     | This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields: atmospheric chemistry; atmospheric dynamics; atmospheric physics; climate modeling; climate physics; land-climate dynamics; atmospheric circulation; paleoclimate; ocean biogeochemical dynamics. |

Students are allowed to enroll in both courses 701-1280-00L & 701-1281-00L Self-Learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.
Objective

The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

Content

The course has the following elements:

Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
Week 2: General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University: https://www.coursera.org/learn/sciwrite?action=enroll
Weeks 6 and 9: Meetings with supervisor to clarify scientific questions
Week 12: Hand-in of written summary (4 pages maximum)
Week 14: Supervisor provides written feedback to the summary document
Week 16: Oral exam about the scientific topic

Literature

Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.

Prerequisites / notice

Prerequisites depend on the chosen field and include successful completion of the listed lecture courses:
- atmospheric dynamics: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- atmospheric chemistry: “Stratospheric Chemistry” (701-1233-00L) or “Tropospheric Chemistry” (701-1234-00L) or “Aerosols I” (402-0572-00L)
- atmospheric physics: “Atmospheric Physics” (701-0475-00L)
- climate physics: “Klimasysteme” (701-0412-00L) or equivalent
- land-climate dynamics: “Land-climate dynamics” (701-1251-00L)
- climate modeling: “Numerical modeling of weather and climate” (701-1216-00L) (parallel attendance possible)
- atmospheric circulation: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- paleoclimate: “Climate History and Paleoclimate” (651-4057-00L)
- ocean biogeochemical dynamics: “Global Biogeochemical Cycles and Climate” (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.
- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

Course Catalogue of ETH Zurich

Minors

Minor in Physical Glaciology

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>101-0289-00L</td>
<td>Applied Glaciology</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>D. Farinotti, A. Bauder, M. Werder</td>
</tr>
</tbody>
</table>

Abstract

The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

Objective

The objectives of the courses are to:
- apply the above knowledge to some case studies inspired by contract-works performed at ETH’s Glaciology section;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

Content

The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacial and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Lecture notes

Digital lecture handouts will be distributed prior to each class.

Literature

Links to relevant literature will be provided during the classes.

Prerequisites / notice

Completed BSc studies. Basic knowledge in computer scripting in any language (e.g. Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
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<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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### 651-4101-00L  
**Physics of Glaciers**  
W 3 credits 3G  
M. Lüthi, F. T. Walter, M. Werder

**Abstract**  
Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

**Objective**  
After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

**Content**  
The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

**Lecture notes**  
Will be provided on Moodle

**Literature**  
A list of relevant literature is available on Moodle

**Prerequisites / notice**  
High-school mathematics and physics knowledge required.

### 651-4077-00L  
**Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)**  
W 3 credits 1V  
University lecturers

**Abstract**  
Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

**Objective**  
Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.

**Content**  
Erosion and sedimentation by glaciers as a function of topography, englacial temperature, sediment balance, sliding and melt water runoff. Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).

**Lecture notes**  
Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

**Literature**  
references in skript

**Prerequisites / notice**  
Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes

### 651-1581-00L  
**Seminar in Glaciology**  
W 3 credits 2S  
A. Bauder, M. Jacquemart

**Abstract**  
Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.

**Objective**  
In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

**Content**  
Selected topics of scientific research in Glaciology

**Lecture notes**  
Copies/pdf of scientific papers will be distributed during the course (moodle interface)

**Prerequisites / notice**  
Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers
The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and, S. Bouchet, L. Winkel

Future climate change can only kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss

Waiting list will be deleted 30.09.2022.

Environmental Sciences until 20.09.2022.

Priority is given to the target groups: Bachelor and Master

Environmental Sciences and PHD Environmental

Sciences until 20.09.2022.

Waiting list will be deleted 30.09.2022.

Abstract
The course introduces the scientific concepts and typical applications of tracers in biogeochemistry. The course covers stable and radioactive isotopes, geochemical tracers and biomarkers and their application in biogeochemical processes as well as regional and global cycles. The course provides essential theoretical background for the lab course "Isotopic and Organic Tracers Laboratory".

Objective
The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and decay modes of relevant radionuclides. They discover the spectrum of possible geochemical tracers and biomarkers, their potential and limitations and get familiar with important applications

Content
Geogenic and cosmogenic radionuclides (sources, decay chains); stable isotopes in biogeochemistry (natural abundance, fractionation); geochemical tracers for processes such as erosion, productivity, redox fronts; biomarkers for specific microbial processes.

Lecture notes
Handouts will be provided for every chapter

Literature
A list of relevant books and papers will be provided

Prerequisites / notice
Students should have a basic knowledge of biogeochemical processes (BSc course on Biogeochemical processes in aquatic systems or equivalent)

Isotopes and Biomarkers in Biogeochemistry

701-1313-00L

W

3 credits

2G

C. Schubert, N. Casacuberta Arola, R. Kipfer

Biogeochemistry of Trace Elements

701-1315-00L

W

3 credits

2G

A. Vogelin, S. Bouchet, L. Winkel

Carbon Mitigation

701-1346-00L

W

3 credits

2G

N. Gruber

Number of participants limited to 100

Priority is given to the target groups: Bachelor and Master Environmental Sciences and PHD Environmental Sciences until 20.09.2022.

Waiting list will be deleted 30.09.2022.

Abstract
Future climate change can only kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss

Objective
The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

Content
From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Lecture notes
None

Literature
Will be identified based on the chosen topic.

Prerequisites / notice
Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

Minor in Biogeochemistry

Minor in Global Change and Sustainability
### 701-0015-00L  
**Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement**  
The lecture takes place if a minimum of 12 students register for it.  

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0015-00L</td>
<td>Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>B. Vienni Baptista, C. E. Pohl, M. Stauffacher</td>
</tr>
</tbody>
</table>

**Abstract**  
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

**Objective**  
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

**Content**  
The seminar covers the following topics:  
1. Theories and concepts of inter- and transdisciplinary research  
2. The specific challenges of inter- and transdisciplinary research  
3. Collaborating between different disciplines  
4. Engaging with stakeholders  
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

**Literature**  
Literature will be made available to the participants:  
available at (open access): http://www.ingentaconnect.com/contentone/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used  
https://naturalsciences.ch/topics/co-producing_knowledge

**Prerequisites / notice**  
Participation in the course requires participants to be working on their own research project.

**Taught competencies**  
Subject-specific Competencies: Concepts and Theories, Problem-solving, Sensitivity to Diversity, Critical Thinking, Self-awareness and Self-reflection  
Method-specific Competencies: Cooperation and Teamwork, Social Competencies: Communication, Personal Competencies: Creative Thinking

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

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

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

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

**Literature**  
Selected scientific articles and book-chapters

**Handouts are provided**

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

**Taught competencies**  
Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Communication, Cooperation and Teamwork, Critical Thinking  
Social Competencies: Problem-solving, Cooperation and Teamwork, Sensitivity to Diversity, Critical Thinking  
Personal Competencies: Critical Thinking

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### 701-1551-00L  
**Sustainability Assessment**  
Does not take place this semester.

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

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

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

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

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

**Lecture notes**  
Handouts are provided

**Literature**  
Selected scientific articles and book-chapters

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

**Taught competencies**  
Subject-specific Competencies: Concepts and Theories, Techniques and Technologies  
Social Competencies: Communication, Cooperation and Teamwork  
Personal Competencies: Creative Thinking

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### 860-0012-00L  
**Cooperation and Conflict Over International Water Resources**  
This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

**Abstract**  
This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

**Objective**  
Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.
The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Limited to 40 students.

Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.

### Minor in Sustainable Energy Use

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0731-00L</td>
<td>Power Market I - Portfolio and Risk Management</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>D. Reichelt, G. A. Koeppel</td>
</tr>
</tbody>
</table>

**Abstract**

Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

**Objective**


**Content**

1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions

3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

**Lecture notes**

Handouts of the lecture

**Prerequisites / notice**

1 excursion per semester, 2 case studies, guest speakers for specific topics.


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Steinfeld, E. I. M. Casati</td>
</tr>
</tbody>
</table>

**Abstract**

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

**Objective**

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

**Lecture notes**

Lecture Notes containing copies of the presented slides.

**Prerequisites / notice**

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>052-0609-00L</td>
<td>Energy and Climate Design I</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>A. Schlüter</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 142 of 2345
Abstract
This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

Objective
At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=11917). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

Content
Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:
1. Local potentials
2. Demand estimation
3. Supply concepts

Lecture notes
Material on moodle serves as lecture notes.

Literature
A list of relevant literature is available at the chair and through moodle.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Assessed</td>
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Seminars and Colloquia

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4095-01L</td>
<td>Colloquium Atmosphere and Climate 1</td>
<td>O</td>
<td>1 credit</td>
<td>1K</td>
<td>H. Joos, H. Wernli, D. N. Bresch, D. Domeisen, N. Gruber, R. Knutti, U. Lohmann, T. Peter, C. Schär, S. Schemm, S. I. Seneviratne, M. Wild</td>
</tr>
</tbody>
</table>

Abstract
The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

Objective
The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1211-01L</td>
<td>Master's Seminar: Atmosphere and Climate 1</td>
<td>O</td>
<td>3 credits</td>
<td>2S</td>
<td>H. Joos, R. Knutti, A. Merrifield König, M. A. Wüest</td>
</tr>
<tr>
<td>701-1211-02L</td>
<td>Master's Seminar: Atmosphere and Climate 2</td>
<td>O</td>
<td>3 credits</td>
<td>2S</td>
<td>H. Joos, R. Knutti, A. Merrifield König, M. A. Wüest</td>
</tr>
</tbody>
</table>

Prerequisites / notice
Attendance is mandatory.
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

**Objective**

Apply scientific project management techniques to your master project, practice the presentation of scientific results and how to chair other students presentations and lead the discussion.

**Content**

In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

**Prerequisites / notice**

Attendance is mandatory.

### 701-1213-00L Introduction Course to Master Studies Atmosphere and Climate

**Number** 701-1213-00L

**Title** Introduction Course to Master Studies Atmosphere and Climate

**Type** O

**ECTS** 2 credits

**Hours** 2G

**Lecturers** H. Joos, T. Peter

**Abstract**

New master students are introduced to the atmospheric and climate research field through keynotes given by the programme’s professors. In several self-assessment and networking workshops they get to know each other and obtain general information and guidance about the organisation of the MSc programme.

**Objective**

The aims of this course are i) to welcome all students to the master program and to ETH, ii) to acquaint students with the faculty teaching in the field of atmospheric and climate science at ETH and at the University of Bern, iii) that the students get to know each other and iv) to assess needs and discuss options for training and education of soft-skills during the Master program and to give an overview of the study options in general.

### Laboratory and Field Courses

The course in the category «lab and field work» are only offered in spring semester.

### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>651-4275-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

The master thesis is supervised by a professor of the D-ERDW or of the Institute for Atmosphere and Climate (IAC, D-USYS), a professor who teaches in the module subjects or a senior scientist who is on the list of "competent leaders of master theses" of the D-ERDW or of the D-USYS (associated with the IAC).

**Objective**

The master programme will be completed by a master thesis on a topic selected from the subject range of the chosen major programme. Students are to prove their skills in working autonomously on a scientific project.

**Prerequisites / notice**

Students are to prove their skills in working autonomously on a scientific project. They document their work in a scientific report.

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0412-AAL</td>
<td>Climate Systems</td>
<td>E-</td>
<td>3 credits</td>
<td>6R</td>
<td>S. I. Seneviratne</td>
</tr>
</tbody>
</table>

**Abstract**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

**Objective**

Introduction of the most important components of the climate systems and their interactions.

**Prerequisites / notice**

Course taught in german, slides in english

**Literature**

A comprehensive list of references is provided in the class. Two books are particularly recommended:


**Course taught in german, slides in english**

**Teaching**

Reto Knutti, several keynotes to special topics by other professors

**Course taught in german, slides in english**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0471-AAL</td>
<td>Atmospheric Chemistry</td>
<td>E-</td>
<td>3 credits</td>
<td>6R</td>
<td>M. Ammann, T. Peter</td>
</tr>
</tbody>
</table>

**Abstract**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

**Objective**

This is a self-study course targeted at Master students who did not follow the bachelor course "atmospheric chemistry" or similar. The course provides a general introduction into atmospheric chemistry.

**Prerequisites / notice**

The learning target of this lecture is a general overview on the most important processes of atmospheric chemistry and the various problems of the anthropogenic change in the structure of Earth's atmosphere.
Content
- Origin and properties of the atmosphere: structure, large scale dynamics, UV radiation
- Thermodynamics and kinetics of gas phase reactions: enthalpy and free energy of reactions, rate laws, mechanisms of bimolecular and
termolecular reactions.
- Tropospheric photochemistry: Photolysis reactions, photochemical O3 formation, role and budget of HOx, dry and wet deposition
- Aerosols and clouds: chemical properties, primary and secondary aerosol sources, phase transfer kinetics, solubility and hygroscopicity,
N2O5 chemistry, SO2 oxidation, secondary organic aerosols
- Air quality: role of planetary boundary layer, summer-versus winter-smog, environmental problems, legislation, long-term trends
- Stratospheric chemistry: Chapman cycle, Brewer-Dobson circulation, catalytic ozone destruction cycles, polar ozone hole, Montreal
protocol
- Global aspects: global budgets of ozone, methane, CO and NOx, air quality - climate interactions

Prerequisites / notice
Basic courses in chemistry and physics are expected.

701-0475-AAL Atmospheric Physics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Objective
Students are able
- to explain the mechanisms of cloud and precipitation formation using knowledge of humidity processes and thermodynamics.
- to evaluate the significance of clouds and aerosol particles for climate and artificial weather modification.

Content
Moist processes/thermodynamics; aerosol physics; cloud formation; precipitation processes, storms; importance of aerosols and clouds for climate and weather modification, clouds and precipitation

Lecture notes
Powerpoint slides and script will be made available

Literature

701-0473-AAL Weather Systems
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Objective
The students are able to
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales and to investigate basic aspects in mountain meteorology.
- basic understanding of the role of moist adiabatic processes for weather systems and why stable water isotopes are useful in this context

Content
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-
Atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; potential vorticity; Alpine dynamics (storms,
orographic wind); planetary boundary layer

Lecture notes
Lecture notes and slides

Literature
Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

701-0461-AAL Numerical Methods in Environmental Physics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Objective
Ability to develop simple numerical schemes and to implement these schemes using the programming language Python. Ability to critically
use more complex numerical models.

Content
Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration
schemes, non-linearity, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-
section of Environmental Science.

Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not
necessary, a Phython introduction is provided). Example programs and tools are supplied.

Literature
List of literature is provided.

701-0106-AAL Mathematics V: Applied Deepening of Mathematics I - III
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Objective
The aim of this lecture is to prepare the students for the more specialised lectures. They should become more familiar with the
mathematical background, the mathematical concepts and most of all with their application and interpretation.

Content
Practical examples from the following areas will be discussed: ordinary differential equations; eigenvalue problems from linear algebra;
systems of linear and nonlinear differential equations; partial differential equations (diffusion, transport, waves).

701-0071-AAL Mathematics III: Systems Analysis
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Objective
This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of
Atmospheric Science, An Introductory Survey

701-0461-AAL Numerical Methods in Environmental Physics

701-0475-AAL Atmospheric Physics

701-0473-AAL Weather Systems

701-0106-AAL Mathematics V: Applied Deepening of Mathematics I - III

701-0071-AAL Mathematics III: Systems Analysis
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

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

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content
Introduction to principles of models; one-dimensional linear box models; multi-dimensional linear box models; nonlinear box models; models in space and time

Lecture notes
Teaching material: book (see literature).

Literature


Atmospheric and Climate Science Master - Key for Type

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

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

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Cognitively Activating Instructions in MINT Subjects

E. Stern

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

Human Intelligence

E. Stern

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective
- Understanding of research methods used in the empirical human sciences
- Understanding findings relevant for education

Research Methods in Educational Science

C. M. Thurn, T. Braas, P. Edelsbrunner

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective
- Getting to know intelligence tests
The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To integrate this knowledge with teacher's work.

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

Objective
- To develop a critical view on existing research and perspectives.
- To develop critical thinking and research skills.

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

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

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

851-0228-00L Formation of Knowledge in STEM Fields in Primary and Secondary School
Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).
This course unit can only be enrolled after successful participation in the course 851-0240-00L “Human Learning (EW 1)”.

Abstract
The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of
an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

Objective
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and
developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school
level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

Content
Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the
formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar
misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the
assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing
of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can
flexibly adapt to the needs of students from lower grades.

Educational Science Teaching Diploma

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

Abstract
This lecture is only apt for students who intend to enrol in the programs “Teaching Diploma” or “Teaching Certificate”. It is about learning in childhood and adolescence.

Objective
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings
on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and
conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers
are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content
Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der
Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzentwicklung unter besonderer Berücksichtigung des
Wissenstransfers; Lernen durch Instruktion und Erkä rungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle
Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen.

Lernformen:
Themen und wissenschaftliche Konstrukte werden zusammen mit ausgewählten wissenschaftlichen Untersuchungen in Form einer
Vorlesung präsentiert. Die Studierenden vertiefen nach jeder Stunde die Inhalte durch die Bearbeitung von Aufträgen in einem
elektronischen Unterrichtsgebuch. Über die Bedeutung des Gelernten für den Schulalltag soll reflektiert werden. Ausgewählte
Tagebuchentwürfe werden in Beginn ihrer Vorlesung thematisiert.

Lecture notes
Folien werden zur Verfügung gestellt.

Literature
Professionelles Handlungswissen für Lehrerinnen und Lehrer. Kohlhammer Verlag

Prerequisites / notice
This lecture is only apt for students who intend to enrol in the programs “Lehrdipolm” or “Didaktisches Zertifikat”. It is about learning in
childhood and adolescence.
### 851-0238-01L Support and Diagnosis of Knowledge Acquisition Processes (EW3)

- **Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the "Teaching Diploma".**

**Prerequisites:** successful participation in 851-0240-00L "Human Learning (EW1)"

**Abstract**
In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**
The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

**851-0242-01L Coping with Psychosocial Demands of Teaching (EW4)**

- **Enrolment possible with Teaching Diploma matriculation, except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW4.**

**Abstract**
Students learn and practice techniques and skills for coping with psychosocial demands of teaching.

**Objective**
(1) You know the basic rules of negotiation and conflict management (e.g., mediation) and can apply them in the school context (e.g., in conversations with parents).
(2) They can apply diverse techniques of classroom management (e.g., prevention of disciplinary problems in the classroom) and know relevant authorities for further information (e.g., legal conditions; crisis intervention).
(3) They know stress coping strategies to prevent burnout (e.g., psychosocial support) and are familiar with relevant institutions.

**Content**
Major themes:
- counseling and counselling techniques
- conflict management and mediation
- classroom management
- supporting students in a psychological crisis
- preventing stress and burnout

**Lecture notes**
Prerequisites / notice

**Prerequisites / notice**

**851-0240-15L Designing Educational Environments in Physical Education (EW2 Sport)**

- **Compulsory course requirements for EW2 Sport: This course is required to be taken prior to EW4 Sport "Outdoor Education: Concepts and Practice" (851-0242-02L)**

**Abstract**
Students learn principles of teaching beyond classroom and regular PE-Lessons:
- Planning and organizing camps and events
- Teaching the "Ergänzungsfach Sport"
- Long-term-curricula in PE

As a practical part students design the Outdoor event in EW4 of the following term

**Objective**
Students know
- How to plan events and camps
- To assess curricula critically and to use them properly
- How to combine theoretical and practical issues in the 'Ergänzungsfach'

**Content**
1. LV Semestereinführung
2. LV Planung Outdoor-Weekend
3. LV Auswertung Outdoor-Event
4. LV Planung Event
5. LV Event-Präsentationen / Schlussveranstaltung

**Prerequisites / notice**
EW2 is compulsory requirement for EW4 Sport

**851-0240-19L Effective Learning Environments (EW 5)**

- **The successful completion of ALL modules relevant for the teacher's diploma is required for participation in this course.**

**Abstract**
The students have to read the book "Lernwirksam unterrichten" from Felten/Stern and they have to answer questions. In individual or small-group sessions will be discussed how insights from learning research can inform classroom practice.

**Objective**
The focus of all classes on educational psychology is on scientific insights which help to reflect on instructional learning. In order to become professionals, teachers have to better understand students' behavior and achievement and thereby become aware of their scope of classroom practice. Students get a final opportunity to ask questions about psychological learning research.

**Literature**
Buch "Lernwirksam unterrichten" (Felten/Stern)

**Prerequisites / notice**
Detailed information: http://www.itvll.ethz.ch/studium/lehre/ew-5.html

**851-0242-07L Human Intelligence**

- **Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).**

**Number of participants limited to 30.**

**This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Intelligence.**

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The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

Number of participants limited to 30.

- Understanding  findings relevant for education
- Getting to know intelligence tests
- Elaborate on the topics learned in the seminar.

This course unit can only be enrolled after successful participation in 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Number of participants limited to 40.

- Get information about recent literature on learning and instruction
- Understand research methods used in the empirical educational sciences

In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

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

In this seminar, students learn about major gender issues in the educational context and the different representations of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

Number of participants limited to 30.

- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher's work.

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

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

This course prepares prospective teachers to supervising and assessing scientific projects at upper secondary school level, particularly Matura theses in STEM subjects at Gymnasium.

1. Assessing the adequacy of Matura thesis topics and defining the scope of a project.
2. Determining and promoting a successful work process.
3. Devising and applying criteria for assessing process, product and presentation of a Matura thesis.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisites / notice

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Notice

- Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.

Number of participants limited to 40.

- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

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

- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher's work.

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

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

Number of participants limited to 40.

- Get information about recent literature on learning and instruction
- Understand research methods used in the empirical educational sciences

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

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

This course prepares prospective teachers to supervising and assessing scientific projects at upper secondary school level, particularly Matura theses in STEM subjects at Gymnasium.

1. Assessing the adequacy of Matura thesis topics and defining the scope of a project.
2. Determining and promoting a successful work process.
3. Devising and applying criteria for assessing process, product and presentation of a Matura thesis.
**Prerequisites / notice**

Focus on STEM subjects (biology, chemistry, computer science, mathematics, and physics) with no explicit discussion of geography or physical education.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>U. Markwalder</td>
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Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in the course 851-0240-00L "Human Learning (EW 1)".

**Abstract**

The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

**Objective**

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

**Content**

Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

### Compulsory Elective Courses Teaching Diploma

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0237-01L</td>
<td>Lesson Design and School Development at Federal Vocational Baccalaureate Schools (UZH)</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Enrolment only possible with Teaching Diploma matriculation.

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 090LLB1 (ATTENTION: Students of Sport Teaching Diploma enroll in course 090LLB1S)

Simultaneous enrolment in course "Lernende an der Berufsmaturitätsschule unterstützen und begleiten" (UZH Module Code: 090LLB2) is compulsory.

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html ("Registering for studies at more than one university, Teaching Diploma", Philosophische Fakultät)

**Abstract**

In this course options for implementing the specifications in the framework curriculum for the vocational baccalaureate are developed and discussed, e.g. guiding principles of BM teaching, difficulties and challenges of interdisciplinary work. The module is designed for teachers at vocational baccalaureate schools and vocational schools of all disciplines.

**Objective**

- Students will be able to select subject content in their lessons based on vocational pedagogy, implement vocational pedagogical requirements for lesson design, incorporate interdisciplinary and cross-curricular approaches.
- Students are familiar with various forms and procedures of performance assessment and feedback as well as lesson design. They are able to implement them, taking into account the different contexts in which young people live and work.
- Students are familiar with the content and significance of basic principles such as the vocational baccalaureate ordinance or school curricula and concepts such as sustainability, lifelong learning or error culture. They can use these aspects for school and teaching development and work cooperatively within the college.

**Prerequisites / notice**

Die Lehrveranstaltung ist seit September 2008 vom Bundesamt für Berufsbildung und Technologie akkreditiert.


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0237-02L</td>
<td>Support and Accompany Learners at the Federal Vocational Baccalaureate School (UZH)</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Enrolment only possible with Teaching Diploma matriculation.

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 090LLB2

Simultaneous enrolment in course "Unterrichtsgestaltung und Schulentwicklung an Berufsmaturitätsschulen" (UZH Module Code: 090LLB1) is compulsory.

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html ("Registering for studies at more than one university, Teaching Diploma", Philosophische Fakultät)

**Abstract**

In this course, pedagogical processes are analyzed and learning and socialization processes are discussed using concrete case studies from teaching at vocational schools and vocational baccalaureate schools. The focus is on the supporting and encouraging role of the teacher and the consideration of the individual life and professional situations of the trainees in their heterogeneity.
Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Handouts from the lecturer and collection of materials on the BSCW server.

- Positioning of vocational school teaching within the dual (trial) system.

Cognitively Activating Instructions in MINT Subjects

This seminar focuses on teaching units in chemistry, physics, and mathematics that have been developed at the MINT Learning Center, T. Braas.

- Students are familiar with a variety of approaches in the areas of individual support, internal differentiation, learning, and problem-solving.

The focus will be on the book "Intelligence: große Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5-10 students) will be discussed.

- Understanding findings relevant for education.
- Getting to know intelligence tests.
- Getting information about recent literature on learning and instruction.

Die Lehrveranstaltung ist seit September 2008 vom Bundesamt für Berufsbildung und Technologie akkreditiert.

Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:

- Understanding research methods used in the empirical human sciences.
- Understanding findings relevant for education.

Autumn Semester 2022
Gender Issues In Education and STEM
We learn from our mistakes, or rather, we hope that we do. Another way to say this is that we can learn from failure. But, what does "failure" mean? And, what, how, and why do we learn from failure? This course covers research from the cognitive, educational, and learning sciences that addresses the role of failure in human learning. Students will critically examine how failure affects thinking, knowledge, creativity, problem-solving, and motivation.

By the end of the course, students should be able to:
- Demonstrate a critical understanding of the role that failure plays in learning
- Discuss how and why failure can benefit learning
- Discuss how and why failure does not facilitate learning
- Apply understanding to a related sub-topic

We learn from our mistakes, or rather, we hope that we do. Another way to say this is that we can learn from failure. But, what does "failure" mean? And, what, how, and why do we learn from failure? This course covers research from the cognitive, educational, and learning sciences that addresses the role of failure in human learning. Students will critically examine how failure affects development of knowledge, creativity, problem-solving, and general thinking and learning. More specifically, they will have the opportunity to question and evaluate the potential relationships between the facets around failure within individual, interactional, cultural, societal, and global contexts through seminal readings and problem-solving activities. Students from any discipline are welcome to this course to learn more about how failure can be harnessed to improve our knowledge, capabilities, innovations, teamwork, and contribute to the larger global world.

Objectives:
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

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

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

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

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

Objective
Understanding research methods used in the empirical educational sciences.
Understanding and critically examining information from scientific journals and media.
Understanding pedagogically relevant findings from the empirical educational sciences.

Objectives:
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

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

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

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

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

Number of participants limited to 30.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

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

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

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

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

Number of participants limited to 12.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Objective
1. Assessing the adequacy of Matura thesis topics and defining the scope of a project.
2. Determining and promoting a successful work process.
3. Devising and applying criteria for assessing process, product and presentation of a Matura thesis.

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

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

Prerequisites / notice
Focus on STEM subjects (biology, chemistry, computer science, mathematics, and physics) with no explicit discussion of geography or physical education.

Number of participants limited to 60.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

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

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

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

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

Number of participants limited to 30.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

Abstract
Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Number of participants limited to 30.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences
<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
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<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
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</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
<td></td>
</tr>
</tbody>
</table>

**Educational Science for Teaching Diploma and TC - Key for Type**

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

**Key for Hours**

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Civil Engineering (General Courses) - Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-1187-00L</td>
<td>Colloquium in Structural Engineering</td>
<td>E-</td>
<td>0 credits</td>
<td>2K</td>
<td>A. Taras, E. Chatzi, A. Frangi, W. Kaufmann, B. Stojadinovic, B. Sudret, M. Vassiliou</td>
</tr>
</tbody>
</table>

**Abstract**
Professors from national and international universities, technical experts from the industry as well as research associates of the institute of structural engineering (IBK) are invited to present recent research results and specific projects from the practice. This colloquium is addressed to members of universities, practicing engineers and interested persons in general.

**Objective**
Learn about recent research results in structural engineering.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-1387-00L</td>
<td>Colloquia in Geotechnics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>A. Puzrin, G. Anagnostou, I. Anastasopoulos</td>
</tr>
</tbody>
</table>

**Abstract**
The Institute for Geotechnical Engineering invites distinguished speakers from research and practice, nationally and internationally. The colloquia are directed towards staff and students from Universities as well as engineers and scientists working in industry. Details can be obtained from www.igt.ethz.ch by following Events & Public Events. Some colloquia are available via webcast.

**Objective**
Learn about recent research results in geotechnics.

### Civil Engineering (General Courses) - Key for Type

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

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
# Civil Engineering Bachelor

## First Year Compulsory Courses

### First Year Examinations

#### First Year Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5 credits</td>
<td>3V+1U</td>
<td>M. Akka Ginosar</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to Linear Algebra</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Basic knowledge of linear algebra as a tool for solving engineering problems. Understanding of abstract mathematical formulation of technical and scientific problems. Together with Analysis we develop the basic mathematical knowledge for an engineer.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>The Modelling competency is taught, applied, and tested, and the Programming competency is applied. Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Calculation with MATLAB will be introduced in the first exercise class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>The lecturer will provide course notes.</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 151-0501-03L | Mechanics I | O | 6 credits | 3V+2U+1K | R. Hopf, E. Mazza |
| Abstract | Basics: Position of a material point, velocity, kinematics of rigid bodies, forces, reaction principle, mechanical power | | | |
| Statics | Groups of forces, moments, equilibrium of rigid bodies, reactions at supports, parallel forces, center of gravity, statics of systems, principle of virtual power, trusses, frames, forces in beams and cables, friction. | | | |
| Objective | The understanding of the fundamentals of statics for engineers and their application in simple settings. | | | |
| Content | Grundlagen: Lage eines materiellen Punktes; Geschwindigkeit; Kinematik starrer Körper, Translation, Rotation, Kreiselung, ebene Bewegung; Kräfte, Reaktionsprinzip, innere und äussere Kräfte, verteilte Flächen- und Raumkräfte; Leistung | | | |
| Literature | Statik: Äquivalenz und Reduktion von Kräftegruppen; Ruhe und Gleichgewicht, Hauptsatz der Statik; Lagerung und Lagerkräfte, Lager bei Balkenträgern und Wellen, Vorgehen zur Ermittlung der Lagerkräfte; Parallele Kräfte und Schwerpunkt; Statik der Systeme, Behandlung mit Hauptsatz, mit Prinzip der virtuellen Leistungen, statisch unbestimmte Systeme; Statisch bestimmte Fachwerke, ideale Fachwerke, Pendelstützen, Knotengleichgewicht, räumliche Fachwerke; Reibung, Haftreibung, Gleitreibung, Gelenk und Lagerreibung, Rollreibung; Seilstatik; Beanspruchung in Stab trägern, Querkraft, Normalkraft, Biege- und Torsionsmoment | | | |
| Lecture notes | Übungsblätter | | | |
| Literature | Sayir, M.B., Dual J., Kaufmann S., Mazza E., Ingenieurmechanik 1: Grundlagen und Statik, Springer | | | |

| 651-0032-00L | Geology and Petrography | O | 4 credits | 2V+1U | K. Rauchenstein, M. O. Saar |
| Abstract | This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups. | | | |
| Objective | This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. | | | |
| Literature | Übungen zum Gesteinsbestimmen und Lesen von geologischen, tektonischen und geotechnischen Karten, einfache Konstruktionen. | | | |
| Lecture notes | Weekly handouts of PPT slides via MyStudies | | | |
| Literature | The course is based on Press & Siever book Dynamic Earth by Grotzinger et al., available to ETH students via https://link.springer.com/book/10.1007/978-3-662-48342-8 | | | |

| 101-0700-00L | Programming for Engineers | O | 4 credits | 2V+2U | B. Sudret, N. Lüthen |
| Abstract | This course is a hands-on introduction to programming with Matlab and Python, oriented at the needs of civil engineers. The course is held in a novel format comprising self-paced tutorials, a project consisting of implementing an engineering application including graphical user interface, and individual meetings with teaching assistants to demonstrate understanding and progress. | | | |
| Objective | Students recognize the usefulness and power of computer tools in civil engineering, and are prepared to independently use Matlab or Python for solving future problems. Students are able to explain basic computer science concepts in simple terms. Students are able to understand and explain the functionality of existing code. Students are able to analyse a simple civil engineering problem in order to partition it into logical blocks and devise an algorithm to systematically solve the problem. Students are able to implement simple imperative algorithms in Matlab and Python and explain the functionalities of their code. They are able to extend existing code with new functionalities. Students are able to validate, test and debug their own code as well as existing code. Students are able to explain the basics of object-oriented programming and are able to extend existing skeleton code to create simple graphical user interfaces. | | | |
| Content | The course is structured into six modules. The first five are using Matlab, while the last introduces Python. 1. Getting to know Matlab: Matlab as a calculator, variables and arrays 2. Programming basics I: iterating and branching 3. Programming basics II: input and output, functions, visualization 4. Introduction to scientific programming: implementing simple algorithms from numerics, statistics and discrete math; validation, testing and debugging 5. From structures to objects to GUI: basics of object-oriented programming, introduction to interactive programming and graphical user interfaces (GUI) 6. Introduction to programming with Python | | | |
A script will be provided. The students will discover the topics of each module through e-tutorials that they will follow at their own pace online.

**Lecture notes**

Additional book (not mandatory):


**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td></td>
<td>Creative Thinking</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<td>Critical Thinking</td>
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</tr>
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<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

**Taught competencies**

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Types</th>
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</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td></td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td></td>
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<tr>
<td>Social Competencies</td>
<td></td>
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<tr>
<td>Personal Competencies</td>
<td></td>
</tr>
</tbody>
</table>

**Literature**

Additional book (not mandatory):


**Taught competencies**

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td></td>
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<tr>
<td>Method-specific Competencies</td>
<td></td>
</tr>
<tr>
<td>Social Competencies</td>
<td></td>
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<tr>
<td>Personal Competencies</td>
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</tr>
</tbody>
</table>

**851-0703-03L Private Construction Law**

Only for Civil Engineering BSc, Spatial Development and Infrastructure Systems MSc and UZH MNF Geographie/Erdsystemwissenschaften.

**Abstract**

This class introduces to practice-relevant basics of construction and real estate law.

**Objective**

Understanding of important legal aspects for the construction practitioner.

**Content**

Introduction (most important sources of construction and real estate law), SIA (Swiss Society of Engineers and Architects) Design Engineering Services Contract, SIA-Norm 118 (SIA General Terms and Conditions for Construction Services), liability of designers/civil engineers, construction insurance, property law for civil engineers, sale of land, contaminated sites, statutory mortgage for contractors, public procurement, litigation in construction and real estate, the civil engineer as expert, What else to know ...

**Lecture notes**

There are 'Lecture Notes' (in German) for this course.

### First Year Examination Block B

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0241-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7</td>
<td>5+2U</td>
<td>M. Akveld</td>
</tr>
</tbody>
</table>

**Abstract**

Mathematical tools for the engineer

**Objective**

Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers. Mathematical formulation of technical and scientific problems.

**Content**

Complex numbers. Calculus for functions of one variable with applications. Simple Mathematical models in engineering.

**Lecture notes**

Wird auf der Vorlesungshomepage zu Verfügung gestellt.

**Literature**

Klaus Dürrschnabel, "Mathematik für Ingenieure - Eine Einführung mit Anwendungs- und Alltagsbeispielen", Springer; online verfügbar unter:

http://link.springer.com/book/10.1007/978-3-8348-2559-9/page/1

Tilo Arens et al., "Mathematik", Springer; online verfügbar unter:

http://link.springer.com/book/10.1007/978-3-642-44919-2/page/1

Meike Akveld und Rene Sperb, "Analysis I", vdf;


Urs Stammbach, "Analysis I/II" (erhältlich im ETH Store);

https://people.math.ethz.ch/~stammb/analysisskript.html

### Bachelor Studies (Programme Regulations 2014)

#### Compulsory Courses 3. Semester

#### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0243-00L</td>
<td>Analysis III</td>
<td>O</td>
<td>3</td>
<td>2+1U</td>
<td>M. Akka Ginosar</td>
</tr>
</tbody>
</table>

**Abstract**

We will model and solve scientific problems with partial differential equations. Differential equations which are important in applications will be classified and solved. Elliptic, parabolic and hyperbolic differential equations will be treated. The following mathematical tools will be introduced: Laplace and Fourier transforms, Fourier series, separation of variables, methods of characteristics.

**Objective**

Learning to model scientific problems using partial differential equations and developing a good command of the mathematical methods that can be applied to them. Knowing the formulation of important problems in science and engineering with a view toward civil engineering (when possible). Understanding the properties of the different types of partial differential equations arising in science and in engineering.
Classification of partial differential equations

Study of the Heat equation general diffusion/parabolic problems using the following tools through Separation of variables as an introduction to Fourier Series.

Systematic treatment of the complex and real Fourier Series

Study of the wave equation and general hyperbolic problems using Fourier Series, D'Alembert solution and the method of characteristics.

Laplace transform and it's uses to differential equations

Application of Laplace transform for beam theory will be discussed.

Time permitting, we will introduce the Fourier transform.

Lecture notes
Lecture notes will be provided

Literature

large part of the material follow certain chapters of the following first two books quite closely.


The course material is taken from the following sources:

Stanley J. Farlow - Partial Differential Equations for Scientists and Engineers


Analysis I and II, insbesondere, gewöhnliche Differentialgleichungen.
Abstract
Dynamics of particles, rigid bodies and deformable bodies: Motion of a single particle, motion of systems of particles, 2D and 3D motion of rigid bodies, vibrations, waves

Objective
This course provides Bachelor students of mechanical and civil engineering with fundamental knowledge of the kinematics and dynamics of mechanical systems. By studying the motion of a single particle, systems of particles, of rigid bodies and of deformable bodies, we introduce essential concepts such as kinematics, kinetics, work and energy, equations of motion, and forces and torques. Further topics include the stability of equilibria and vibrations as well as an introduction to the dynamics of deformable bodies and waves in elastic rods.

Throughout the course, the basic principles and application-oriented examples presented in the lectures and weekly exercise sessions help students acquire a proficient background in engineering dynamics, learn and embrace problem-solving techniques for dynamical engineering problems, gain cross-disciplinary expertise (by linking concepts from, among others, mechanics, mathematics, and physics), and prepare students for advanced courses and work on engineering applications.

Content
1. Motion of a single particle: kinematics (trajectory, velocity, acceleration), forces and torques, constraints, active and reaction forces, balance of linear and angular momentum, work-energy balance, conservative systems, equations of motion.
2. Motion of systems of particles: internal and external forces, balance of linear and angular momentum, work-energy balance, rigid systems of particles, particle collisions, mass accretion/loss.
3. Motion of rigid bodies in 2D and 3D: kinematics (angular velocity, velocity and acceleration transfer, instantaneous center and axis of rotation), balance of linear and angular momentum, work-energy balance, angular momentum transport, inertial vs. moving reference frames, apparent forces, Euler equations.
5. Introduction to waves and vibrations in deformable elastic bodies: local form of linear momentum balance, waves and vibrations in slender elastic rods.

Lecture notes
Lecture notes (a scriptum) will be available on Moodle. Students are strongly encouraged to take their own notes during class.

Literature
A complete set of lecture notes (a scriptum) is available on Moodle. Further reading materials are suggested but not required for this class. All course materials (including lecture notes, exercise problems, etc.) are available on Moodle.

Prerequisites / notice
All course materials (including lecture notes, exercise problems, etc.) are available on Moodle.

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

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

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

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

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0113-00L</td>
<td>Theory of Structures I</td>
<td>O</td>
<td>5</td>
<td>3V+2U</td>
<td>B. Sudret</td>
</tr>
</tbody>
</table>

Abstract
Introduction to structural mechanics, statically determinate beams and frame structures, trusses, stresses and deformations, statically indeterminate beams and frame structures (force method)

Objective
- Understanding the response of elastic beam and frame structures
- Ability to correctly apply the equilibrium conditions
- Understanding the basics of continuum mechanics
- Computation of stresses and deformations of elastic structures
- Ability to apply the force (flexibility) method for statically indeterminate structures

Content
- Equilibrium, reactions, static determinacy
- Internal forces (normal and shear forces, moments)
- Arches and cables
- Elastic trusses
- Influence lines
- Basics of continuum mechanics
- Stresses in elastic beams
- Deformations in Euler-Bernoulli and Timoshenko beams
- Energy theorems
- Statically indeterminate systems (Force method)

Lecture notes
Bruno Sudret, "Einführung in die Baustatik" (2021)

Literature
* Bruno Sudret, "Baustatik - Eine Einführung", Springer Vieweg

The lecture Steel Structures II complements the knowledge acquired in part I by providing students with additional theoretical and practical background. The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field. After completion of the year-long course in Steel Structures I+II, students will have at their disposal a wide and detailed set of skills concerning the modern practice for steel and composite structures design and have a deep understanding of its theoretical & scientific background. The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

Content overview:
- Structural forms, analysis techniques and modelling of multi-storey buildings and bridges.
- Structural analysis (deformations, internal forces, stresses and strains) in steel-concrete composite girders considering the effects of creep, shrinkage and shear deformations.
- Elastic and plastic longitudinal shear transfer mechanisms and effects
- Plate buckling of unstiffened and stiffened panels
- Fatigue resistance and safe life assessment: phenomenon and design approaches
- Special topics of steel connection design
- Detailing, drafting, fabrication and erection, cost determination in constructional steelwork

Lecture notes: Lecture notes and slides. Worked Examples with summary of theory. Design aids and formula collections. Videos of lectures.
The world's growing population, changing demographics, and changing climate pose formidable challenges to humanity's ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth's growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.

More specifically upon completion of the course, you will have gained insight into:

- how to structure the large amount of information that is often associated with attempting to modify complex systems
- how to set goals and define constraints in the engineering of complex systems
- how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
- how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future
- how to assess values of benefits to stakeholders that are not in monetary units
- how to assess whether it is worth obtaining more information in determining optimal solution
- how to take a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture
- the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.
The weekly lectures are structured as follows:

1. **Introduction** – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms. A high-level overview of the main principles of System Engineering. An introduction to the example that we will be working with throughout most of the course. The expectations of your efforts throughout the semester.

2. **Situation analysis** – How to structure the large amount of information that is often associated with attempting to modify complex systems.

3. **Goals and constraints** – How to set goals and constraints to identify the best solutions as clearly as possible.

4. **Generation of possible solutions** – How to generate possible solutions to problems, considering multiple stakeholders.

5. **Analysis – 1/5** – The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, display, weighting, and expected value.

6. **Analysis – 2/5** – The idea behind the supply and demand curves and revealed preference methods.

7. **Analysis – 3/5** – The concept of equivalence, including the time value of money, interest, life times and terminal values.

8. **Analysis – 4/5** – The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Marginal rates of return and internal rates of return.

9. **Analysis – 5/5** – How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.

10. **Evaluation of solutions** – Regardless how sophisticated an analysis is, it requires that decision makers stand back and critically evaluate the results. This week we discuss the aspects of evaluating the results of an analysis.

11. **Operations research – 1/4** – Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. This week we discuss linear programming and the simplex method.

12. **Operations research – 2/4** – How sensitivity analysis is conducted using linear programming.

13. **Operations research – 3/4** – How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.

14. **Operations research – 4/4** – How to set up and solve problems when there are multiple objectives.

The course uses a combination of qualitative and quantitative approaches. The quantitative analyses requires the use of Excel. An introduction to Excel will be provided in one of the help sessions.

**Lecture notes**
- The lecture materials consist of a script, the slides and example calculations in Excel.
- The lecture materials will be distributed via Moodle two days before each lecture.

**Literature**
Appropriate literature in addition to the lecture materials will be handed out when required via Moodle.

**Prerequisites / notice**
This course has no prerequisites.

### Taught competencies

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

**Hydrology**

<table>
<thead>
<tr>
<th>102-0293-00L</th>
<th>Hydrology</th>
<th>O</th>
<th>3 credits</th>
<th>2G</th>
<th>P. Burlando</th>
</tr>
</thead>
</table>

**Abstract**
The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.

**Objective**
Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.
The hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

Precipitation: mechanisms of precipitation formation, precipitation measurements, variability of precipitation in space and time, precipitation regimes, point/basin precipitation, isohyetal method, Thiessen polygons, storm rainfall, design hyetograph.

Interception: measurement and estimation.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton's equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnian surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – baseflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rationale, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Snow (and ice) hydrology: snow characteristic variables and measurements, estimation of snowmelt processes by the energy budget equation and conceptual melt models (temperature index method and degree-day method), snowmelt runoff.
Introduction into the basic and practical knowledge of important building materials and testing methods. 

Methodology:
Excursion with mission, lectures, autonomous work, poster session, role playing, workshop, exemplary plenary review.

Deliveries:
Poster, sketches, service criteria agreement and basis of design, static calculations, plans, models.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>101-0006-10L</td>
<td>Bachelor’s Thesis</td>
<td>O</td>
<td>8 credits</td>
<td>17D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
Introduction into the basic and practical knowledge of important building materials and testing methods.

Objective
Encourages students to show independence and to produce structured work.

Content
- Introduction of material testing equipment, with various examples of experiments on metals (tensile behaviour, hardness, bending and impact loading).
- Theoretical background and practical aspects of concrete technology: mixture design, casting and setting; determination of mechanical properties.
- Properties of bricks and mortar: individual materials and the composite brickwork. Parameters like strength, Youngs modulus, water absorption and thermal conductivity are determined.
- Understanding the characteristic properties of wood: anisotropy, hygroscopic behaviour, shrinkage and swelling, and effect of size on strength. Introduction to test-methods for wood and wood-products.
- Introduction into the basics of scanning electron microscopy: practical exercises with the Environmental Scanning Electron Microscope (ESEM).
- Introduction to fundamentals of Finite Element Methods and their application in examples.
- Introduction to durability of building materials and building structures: assessment of potentials for detecting and locating corrosion of steel reinforcement in concrete.

Lecture notes
For each topic a script will be provided, that can be downloaded under www.ifb.ethz.ch/education

Bachelor’s Thesis

Recommended Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0599-10L</td>
<td>New Materiality for the Passage Notre Dame</td>
<td>W</td>
<td>2 credits</td>
<td>4P</td>
<td>G. Habert</td>
</tr>
</tbody>
</table>

Abstract
The workshop aims at developing low carbon and long lasting materials for the renovation of the passage Notre Dame.

Objective
Students will work to develop materials from on-site resources: earth, crushed bricks and concrete, plaster and stone. Students will learn about embodied emissions of material production and how to overcome durability issues related with low carbon materials. It’s an hands-on workshop which lasts 10 days and is closed by a presentation in front of the main actors of the project: city of Paris, architects, industries.

Content
On the 27th June 2022, the team led by landscape designer Bas Smets with GRAU as urban planners and architects and Neufville-Gayet architects won the competition of the surroundings of Notre Dame Cathedral. They won with the idea to develop a material made with the raw elements from the site that can contribute to a long term discussion between the material history and future use of an underground space by the next generations. Based on the first mix design developed, this workshop aims to deepen the research on this material potential.

The workshop is articulated around central questions:
How to design a material for eternity if it is made out rubbles of concrete, earth and stone?
Should we design for eternity or accept decay?
And more fundamentally, how much carbon emission is it reasonable to emit for a project that will transform the main square in front of an eight hundred years old cathedral? This raises the question of what heritage do we want to bequeath to the next generation? A Cathedral square and/or a climate and functioning ecosystem that allows them to thrive?

The workshop is based on a combination of hands-on experiments and guest lectures on the architectural intention around Notre Dame renovation, on Life Cycle Assessment and material science of building materials.

The first week explores the influence of processing and material mix design on colors and textures.
The second week dives into durability questions, maintenance and transformations over decades and centuries.

By the end of the workshop, the students will present by group their work to selected stakeholders involved in the project as well as key experts from architecture preservation, material and sustainability science.

Low Carbon materials explored during workshop is mainly poured earth, or earth concrete, which is a new technology well adapted to cities areas. The earth as liquid form is poured into a formwork and uncast after several hours to produce wall elements. Floors can be also done with this technology as it is currently done with concrete slab. It is a local material when excavated material from the site is used. It is nearly zero carbon as the additives used to modify its properties (water resistance, strength, fluidity) require low energy for their production (bio-additives...) and circular as the material can be returned to nature without environmental and societal impact. We will work with earth, limestone, plaster and demolished bricks and concrete as they are the main materials available in Paris.

Prerequisites / notice
A strong motivation to hands on experiments and a deep commitment to sustainability.

Science in Perspective

see Science in Perspective: Type A: Enhancement of
### Language Courses

**see Science in Perspective: Language Courses ETH/UZH**

<table>
<thead>
<tr>
<th>Civil Engineering Bachelor - Key for Type</th>
<th>Key for Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>O  Compulsory</td>
<td>V lecture</td>
</tr>
<tr>
<td>W+ Eligible for credits and recommended</td>
<td>G lecture with exercise</td>
</tr>
<tr>
<td>W  Eligible for credits</td>
<td>U exercise</td>
</tr>
<tr>
<td></td>
<td>S seminar</td>
</tr>
<tr>
<td></td>
<td>K colloquium</td>
</tr>
<tr>
<td>E- Recommended, not eligible for credits</td>
<td>P practical/laboratory course</td>
</tr>
<tr>
<td>Z  Courses outside the curriculum</td>
<td>A independent project</td>
</tr>
<tr>
<td>Dr Suitable for doctorate</td>
<td>D diploma thesis</td>
</tr>
<tr>
<td>W+ Eligible for credits</td>
<td>R revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
The goal is that at the end of this course students should have a good understanding of the different project management knowledge areas, the phases required for successful project management, and the role of a project manager. To demonstrate this, students will work in groups in different case studies to apply the concepts, tools and techniques presented in the class.

Two 3 to 4 hours sessions towards the end of the lecture series will introduce a practical project to allow the teams to demonstrate the tools and techniques learned during the semester. The course will have a final quiz that will be graded.

The main content of the course is summarized in the following topics:
- Project and organization structures
- Project scheduling
- Resource management
- Project estimating
- Project financing
- Risk management
- Project Reporting
- Interpersonal skills

The slides for the class will be available for download from Moodle at least one day before each class. Copies of all necessary documents will be distributed at appropriate times.

The students will be randomly assigned to teams. Students will be graded as a team based on the final Project report and the in-class oral presentation of the Project Proposal as well as a final exam (50% exam and 50% project report and presentation). Homework will not be graded but your final report and presentation will consist mostly of your homework assignments consolidated and put in a report and presentation format.

### Major Courses

#### Major in Construction and Maintenance Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>104-0427-00L</td>
<td>Project Management for Construction Projects</td>
<td>O</td>
<td>4</td>
<td>3S</td>
<td>J. J. Hoffman</td>
</tr>
</tbody>
</table>

Abstract
This course is designed to lay down the foundation of the different concepts, techniques, and tools for successful project management of construction projects.

Objective
The goal is that at the end of this course students should have a good understanding of the different project management knowledge areas, the phases required for successful project management, and the role of a project manager. To demonstrate this, students will work in groups in different case studies to apply the concepts, tools and techniques presented in the class.

Content
The main content of the course is summarized in the following topics:
- Project and organization structures
- Project scheduling
- Resource management
- Project estimating
- Project financing
- Risk management
- Project Reporting
- Interpersonal skills

Lecturers
J. J. Hoffman

The students will be randomly assigned to teams. Students will be graded as a team based on the final Project report and the in-class oral presentation of the Project Proposal as well as a final exam (50% exam and 50% project report and presentation). Homework will not be graded but your final report and presentation will consist mostly of your homework assignments consolidated and put in a report and presentation format.
Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies,
system design and line planning for different situations,
timetabling and tactical planning, and related mathematical approaches
operations, and quantitative support to operational problems,
evaluation of public transport systems.

Content
Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes
Lecture slides are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
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<tr>
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<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td>Project Management</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
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</table>

Infrastructure Management 1: Process 0 6 credits 2G B. T. Adey

101-0509-00L

Abstract
Infrastructre asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods of time. This course provides an overview of the process, from setting goals to developing intervention programs to analyzing the process itself. It consists of weekly lectures and a group project. Additionally, there is a weekly help session.
There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines and much of the research, however, are focused on only part of the large complex problem of infrastructure asset management.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clear understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will
• understand the main tasks of an infrastructure manager and the complexity of these tasks,
• understand the importance of setting goals and constraints in the management of infrastructure,
• be able to predict the deterioration of individual assets using discrete states that are often associated with visual inspections,
• be able to develop and evaluate simple management strategies for individual infrastructure assets,
• be able to develop and evaluate intervention programs that are aligned with their strategies,
• understand the principles of guiding projects and evaluating the success of projects,
• be able to formally model infrastructure management processes, and
• understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.

Content

The weekly lectures are structured as follows:
1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.
2. Positioning infrastructure management in society: As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.
3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.
4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.
5. Help session 1
6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.
7. Determining and justifying monitoring - Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.
8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.
9. Help session 2
10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.
11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.
12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.
13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.
14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

Lecture notes
• The lecture materials consist of handouts, the slides, and example calculations in Excel.
• The lecture materials will be distributed via Moodle two days before each lecture.

Literature
Appropriate literature will be handed out when required via Moodle.

Prerequisites / notice
This course has no prerequisites.
Taught competencies

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**

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

**Personal Competencies**

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

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### 101-0577-00L An Introduction to Sustainable Development in the Built Environment

**Abstract**

In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict. What does it mean for the built environment? This course provides an introduction to the notion of sustainable development when applied to our built environment.

**Objective**

At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmetal aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

**Content**

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

**Methods**

- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

**Main issues:**

- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world

- Synthesis: Transition to sustainable development

**Lecture notes**

All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

**Literature**

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

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### Major in Geotechnical Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0317-00L</td>
<td>Tunnelling I</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Anagnostou, A. Nordas, E. Pimentel</td>
</tr>
</tbody>
</table>

**Abstract**

Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.

**Objective**

Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.
Numerical analysis methods in tunnelling.
Conventional excavation methods (full face, top heading and bench, side drift method, ...)
Auxiliary measures:
- Injections
- Jet grouting
- Ground freezing
- Drainage
- Forepoling
- Face reinforcement

Lecture notes
Autographieblätter

Literature
Empfehlungen

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>Assessed</td>
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</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Assessed</th>
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<tbody>
<tr>
<td></td>
<td>Decision-making</td>
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</table>

101-0357-00L Theoretical and Experimental Soil Mechanics
Prerequisites: Mechanics I, II and III.

The number of participants is limited to 60 due to the existing laboratory equipment! Students with major in Geotechnical Engineering have priority. Registrations will be accepted in the order they are received.

Abstract
Overview of soil behaviour
Explanation of typical applications: reality, modelling, lab tests with transfer of results to practical examples

Consolidation theory and typical applications
Triaxial tests: consolidation & shear, drained & undrained response
Plasticity theory & Critical State Soil Mechanics, Cam Clay
Application of plasticity theory
Introduction to physical modelling

Objective
(1) Extend knowledge of theoretical approaches that can be used to describe soil behaviour.
(2) Offer the opportunity to perform hands on element tests required for constitutive model calibration.
(3) Enable students to select an appropriate constitutive model and calibrate it using element test performed in the lab.
(4) Enable students to carry out FE analyses for realistic geotechnical applications.

Content
Overview of soil behaviour
Discussion of general gaps between basic theory and soil response
Stress paths in practice & in laboratory tests
Explanation of typical applications: reality, modelling, laboratory tests with transfer of results to the practical examples
Consolidation theory for incremental and continuous loading oedometer tests and typical applications in practice
Triaxial & direct shear tests: consolidation & shear, drained & undrained response
Plasticity theory & Critical State Soil Mechanics, Cam Clay
Application of plasticity theory
Introduction to physical modelling with emphasis on centrifuge modelling

Lecture notes
Printed script with web support
Exercises

Literature
https://moodle-app2.let.ethz.ch/

Pre-requisites / notice
Pre-requisites: Fundamental knowledge of solid and soil mechanics.

The theoretical part of the course will be covered by problem-based lectures. The experimental part will be covered by hands-on element tests performed by the students in the laboratory. These experimental results will be instrumental in the calibration of advanced soil constitutive models. The connection between the experimental and theoretical parts of the course will be facilitated by means of numerical investigations (i.e., FE analyses), including the selection and calibration of relevant constitutive models. The numerical investigations shall be documented by the students in a final report.

Laboratory equipment will be available for 60 students. Students registered for the Geotechnics Specialty in Masters will be given priority as follows: (1) 2nd year students; (2) 1st year students, (3) doctoral students taking the class for their qualifying exam; Further students will be admitted on a first-come-first-served basis.

101-0307-00L Design and Construction in Geotechnical Engineering

Abstract
This lecture deals with the practical application of the knowledge gained in the fundamental lectures from the Bachelor degree. The basics of planning and design of geotechnical structures will be taught for the main topics geotechnical engineers are faced to in practice.

Objective
Transfer of the fundamental knowledge taught in the Bachelor degree to practical application.

Ability to plan and design geotechnical structures based on the state of the art.

Content
Introduction to Swisscode SIA
Foundations and settlements
Pile foundations
Excavations
Stops
Soil nailing
Reinforced geosystems
Ground improvement
River levees

Lecture notes
Script in the form of chapters and powerpoint overheads with web support (moodle-app2.let.ethz.ch)
Exercises

Literature
Relevant literature will be stated during the lectures

Prerequisites / notice
Pre-condition: Successful examinations (pass) in the geotechnical studies (soil mechanics and ground engineering, each 5 credits) in the Bachelor degree of Civil Engineering (ETH), or equivalent for new students.

The lecture contains at least one presentation from practice.

101-0369-00L Forensic Geotechnical Engineering

Prerequisites: successful participation in “Geotechnical Engineering” (101-0315-00L) or an equivalent course.
Abstract
In this course selected famous geotechnical failures are investigated with the following purpose: (a) to deepen understanding of the geotechnical risks and possible solutions; (b) to practice design and analysis methods; (c) to learn the techniques for investigation of failures; (d) to learn the techniques for mitigation of the failure damage.

Objective
In this course selected famous geotechnical failures are investigated with the following purpose: (a) to deepen understanding of the geotechnical risks and possible solutions; (b) to practice design and analysis methods; (c) to learn the techniques for investigation of failures; (d) to learn the techniques for mitigation of the failure damage.

Content
Failure due to the loading history
Failure due to excessive settlements
Failure due to the leaning instability
Bearing capacity failure
Excavation failure
Failure in the creeping landslides
Failure evolution in submarine landslides
Construction in the landslide influence zone
Delayed failure in snow avalanches

Lecture notes
Lecture notes
Exercises

Literature

Prerequisites / notice
The course is given in the first MSc semester.
Prerequisite: Basic knowledge in Geotechnical Engineering (Course content of “Grundbau” or similar lecture).

Taught competencies

Subject-specific Competencies
- Concepts and Theories: Assessed
- Techniques and Technologies: Not assessed

Method-specific Competencies
- Analytical Competencies: Assessed
- Decision-making: Assessed
- Media and Digital Technologies: Not assessed
- Problem-solving: Assessed
- Project Management: Not assessed

Social Competencies
- Communication: Not assessed
- Cooperation and Teamwork: Not assessed
- Customer Orientation: Not assessed
- Leadership and Responsibility: Not assessed
- Self-presentation and Social Influence: Not assessed
- Sensitivity to Diversity: Not assessed
- Negotiation: Not assessed

Personal Competencies
- Adaptability and Flexibility: Not assessed
- Creative Thinking: Assessed
- Critical Thinking: Assessed
- Integrity and Work Ethics: Not assessed
- Self-awareness and Self-reflection: Not assessed
- Self-direction and Self-management: Not assessed

Major in Structural Engineering

<table>
<thead>
<tr>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0117-00L</td>
<td>Theory of Structures III</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>B. Stojadinovic</td>
</tr>
</tbody>
</table>

Abstract
This course focuses on the axial, shear, bending and torsion load-deformation response of continuous elastic prismatic structural elements such as rods, beams, shear walls, frames, arches, cables and rings. Additional special topics, such as the behavior of inelastic prismatic structural elements or the behavior of planar structural elements and structures, may be addressed time-permitting.

Objective
After passing this course students will be able to:
1. Explain the equilibrium of continuous structural elements.
2. Formulate mechanical models of continuous prismatic structural elements.
3. Analyze the axial, shear, bending and torsion load-deformation response of prismatic structural elements and structures assembled using these elements.
4. Determine the state of forces and deformations in rods, beams, frame structures, arches, cables and rings under combined mechanical and thermal loading.
5. Use the theory of continuous structures to design structures and understand the basis for structural design code provisions.

Content
This is the third course in the ETH series on theory of structures. Building on the material covered in previous courses, this course focuses on the axial, shear, bending and torsion load-deformation response of continuous elastic prismatic structural elements such as rods, beams, shear walls, frames, arches, cables and rings. Additional special topics, such as the behavior of inelastic prismatic structural elements or the behavior of planar structural elements and structures may be addressed if time permits. The course provides the theoretical background and engineering guidelines for practical structural analysis of modern structures.

Lecture notes
Electronic copies of the learning material will be managed using Moodle. The learning material includes the lecture presentations, additional reading, and exercise problems and solutions. Lectures are streamed live and recorded on the ETH Video Portal.

Literature

Prerequisites / notice
Working knowledge of theory of structures, as covered in ETH course Theory of Structures I (Baustatik I) and Theory of Structures II (Baustatik II) and ordinary differential equations. Basic knowledge of structural design of reinforced concrete, steel or wood structures. Familiarity with structural analysis computer software and computer tools such as Matlab, Mathematica, Mathcad or Excel.
Within this course, the students are able to:

- deepen their understanding of structural concrete models and apply them to general design problems, including the assessment of existing structures.
- enhance their knowledge about the load-deformation response of reinforced and prestressed concrete structures.
- identify and assess the limits of applicability of limit analysis methods.
- recognise the assumptions of models suitable for computer-aided structural design and use in a critical way structural concrete design software.
- evaluate the long-term behaviour and the behaviour under fire conditions of concrete structures.
- assess the behaviour of fibre reinforced concrete structures.

Fundamentals (structural analysis, theorems of limit analysis, applicability of limit analysis methods); shear walls and girders (stress fields and truss models, deformation capacity, membrane elements with yield conditions and load-deformation behaviour, computer-aided structural design); slabs (equilibrium solutions, yield conditions, shear and punching shear); fibre reinforced concrete (mechanical behaviour, applications); long term effects; fire behaviour.

Lecture notes
Lecture notes see: http://www.concrete.ethz.ch

Literature

Steel Structures III provides in-depth theoretical background and practical knowledge on advanced design topics in steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. Students will learn how to solve complex structural engineering tasks in larger building projects, e.g. through the use and correct design of large-span slim-floor girders and ultra-slender composite columns, or the use of glazing and cable structures as principal load-carrying components. They learn how steel structures behave under fire conditions and how they can be protected and designed accordingly. Finally, students learn about the fundamental aspects governing the design of specialty steel structures, such as thin-walled cold-formed sections, crane girders, masts and storage tanks.

The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

The course will give an overview on the design of specialty steel structures, such as crane girders, masts and storage tanks.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Pattern</th>
<th>Literature</th>
</tr>
</thead>
</table>

Objectives:
- Compute the dynamic response of structural systems to harmonic, periodic, pulse, and impulse excitation using time-history and response spectrum methods.
- Model structural systems using single-degree-of-freedom and multiple-degree-of-freedom models.
- Use second-order differential equations to theoretically and numerically model the dynamic equilibrium of structural systems.

Prerequisites / notice:
- Basic course on probability theory and statistics

Content:
Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro codes usually provide a framework that guarantees safety and reliability. However, the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

<table>
<thead>
<tr>
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<th>Pattern</th>
<th>Literature</th>
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</thead>
<tbody>
<tr>
<td>101-0157-01L</td>
<td>Structural Dynamics and Vibration Problems</td>
<td>3</td>
<td>W</td>
<td>S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.</td>
</tr>
</tbody>
</table>

Objectives:
- Fundamentals of structural dynamics are presented. Computing the response of elastic single and multiple DOF structural systems subjected to harmonic, periodic, pulse, and impulse excitation is discussed. Practical solutions to vibration problems in flexible structures under diverse excitations are developed.
- After successful completion of this course the students will be able to:
  1. Explain the dynamic equilibrium of structures under dynamic loading.
  2. Use second-order differential equations to theoretically and numerically model the dynamic equilibrium of structural systems.
  4. Compute the dynamic response of structural systems to harmonic, periodic, pulse, and impulse excitation using time-history and response spectrum methods.
  5. Use dynamics of structures to identify the basis for structural design code provisions related to dynamic loading.

Prerequisites / notice:
- Basic course on probability theory and statistics

Content:
After successful completion of this course the students will be able to:

1. Explain the dynamic equilibrium of structures under dynamic loading.
2. Use second-order differential equations to theoretically and numerically model the dynamic equilibrium of structural systems.
4. Compute the dynamic response of structural system to harmonic, periodic, pulse, and impulse excitation using time-history and response spectrum methods.
5. Use dynamics of structures to identify the basis for structural design code provisions related to dynamic loading.

Lecture notes:
Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.
M. Motavalli

Field of application of timber structures; Timber as building material (wood structure, physical and mechanical properties of wood and long duration effects and their consideration in structural analysis and detailing).

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

All material is provided online via Moodle.

101-0167-01L

Fibre Composite Materials in Structural Engineering

W 3 credits 2G M. Motavalli

Abstract
1) Lamina and Laminate Theory
2) FRP Manufacturing and Testing Methods
3) Design and Application of Externally Bonded Reinforcement to Concrete, Timber, and metallic Structures
4) FRP Reinforced Concrete, All FRP Structures
5) Measurement Techniques and Structural Health Monitoring

Objective
At the end of the course, you shall be able to
1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessary testing and SHM techniques for FRP structures,
3) Continue your education as a phd student in this field.

Content
Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes
Power Point Presentations available online at www.empa.ch/abt303


3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019

4) SIA166 (2004) Klebebewehrungen (Externally bonded reinforcement), Schweizerischer Ingenieur- und Architektenverein SIA

Prerequisites / notice
1) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components
2) Working with Composite Materials in the Laboratory (application, testing, etc)

101-0637-01L

Timber Structures I

W 3 credits 2G A. Frangi, I. Burgert, G. Fink, R. Steiger

Abstract
Conceptual design, detailing and structural analysis of multi-storey timber buildings as well as timber roof structures and halls.

Objective
Comprehension and application of basic knowledge of structural timber design including material behaviour especially anisotropy, moisture and long duration effects and their consideration in structural analysis and detailing.

Content
Field of application of timber structures; Timber as building material (wood structure, physical and mechanical properties of wood and wood-based products); Durability; Principles of design and dimensioning; Connections (dowels, nails, screws, glued connections); Timber components and assemblies (mechanically jointed beams, trusses); Design and detailing of multi-storey timber buildings as well as timber roof structures and halls.

Lecture notes
Autography Timber Structures
Copies of lecture slides

Literature
Timber design tables HBT 1, Lignum
Swiss Standard SIA 265
Swiss Standard SIA 265/1
Eurocode 5

052-0609-00L

Energy and Climate Design I

W 2 credits 2G A. Schlüter

Abstract
This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

Objective
At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=1191?). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

Content
Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:
1. Local potentials
2. Demand estimation
3. Supply concepts

Lecture notes
Material on moodle serves as lecture notes.

Literature
A list of relevant literature is available at the chair and through moodle.
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders.

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning, timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.
Content
Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes
Lecture slides are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Taught competencies

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

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

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

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

101-0437-00L Traffic Engineering O 6 credits 4G S. Mousavi, A. Kouvelas, M. Makridis

Abstract
Fundamentals of traffic flow theory and control.

Objective
The objective of this course is to fully understand the fundamentals of traffic flow theory in order to effectively manage traffic operations. By the end of this course students should be able to apply basic techniques to model different aspects of urban and inter-urban traffic performance, including congestion.

Content
Introduction to fundamentals of traffic flow theory and control. Includes understanding of traffic data collection and processing techniques, as well as data analysis, traffic modeling, and methodologies for traffic control.

Lecture notes
The lecture notes and additional handouts will be provided during the lectures.

Literature
Additional literature recommendations will be provided during the lectures.

Prerequisites / notice
Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)
Special permission from the instructor can be requested if the student has not taken Verkehr III

101-0417-00L Transport Planning Methods W 6 credits 4G K. W. Axhausen

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.


Objective
The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport.
Ideal foundation for Aviation II - Management of Air Transport.

Content
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

Lecture notes
Preparation materials & slides are provided prior to each class

Literature
The lecture is planned as class teaching.

Prerequisites / notice
The lecture is planned as class teaching.

Taught competencies

<table>
<thead>
<tr>
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<th>Techniques and Technologies</th>
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<tbody>
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<td>Media and Digital Technologies</td>
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<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td></td>
<td>not assessed</td>
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</tbody>
</table>

Social Competencies

| Communication                                        |                            | assessed |
| Cooperation and Teamwork                             |                            | not assessed |
| Customer Orientation                                 |                            | assessed |
| Leadership and Responsibility                        |                            | not assessed |
| Sensitivity to Diversity                             |                            | assessed |

Personal Competencies

| Adaptability and Flexibility                         |                            | not assessed |
| Creative Thinking                                    |                            | assessed |
| Critical Thinking                                    |                            | assessed |

227-0523-00L Railway Systems I W 6 credits 4G M. Meyer

Abstract
Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

Objective
- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content
EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrreibung

2 Vollbahnfahrzeuge:
2.1 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebssysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung

3 Infrastruktur:
3.1 Fahrdraht
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen

4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
Betriebszentrale SBB, Zürich Flughafen
Reparatur und Unterhalt, SBB Zürich Altstetten
Fahrzeugfertigung, Stadler Bussnang

Lecture notes
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.
Infrastructure asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods of time. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines are written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clear understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will
• understand the main tasks of an infrastructure manager and the complexity of these tasks,
• understand the importance of setting goals and constraints in the management of infrastructure,
• be able to predict the deterioration of individual assets using discrete states that are often associated with visual inspections,
• be able to develop and evaluate simple management strategies for individual infrastructure assets,
• be able to develop and evaluate intervention programs that are aligned with their strategies,
• be able to formally model infrastructure management processes, and
• understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.

The weekly lectures are structured as follows:
1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.
2. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.
3. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.
4. Help session 1
5. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.
6. Determining and justifying monitoring - Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.
7. Help session 2
8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.
9. Help session 3
10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.
11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.
12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.
13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.
14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

The lecture materials consist of handouts, the slides, and example calculations in Excel. The lecture materials will be distributed via Moodle two days before each lecture.

Appropriate literature will be handed out when required via Moodle.

This course has no prerequisites.
Main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems and to highlight how transport infrastructure investments can affect the location, size and composition of such systems.

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong microfoundations and allow for precise policy recommendations.

The course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong microfoundations and allow for precise policy recommendations.

Information: Enrolment of Hydraulic Engineering II is strongly based on Hydraulic Engineering (101-0206-00L) previously since Hydraulic Engineering II is not recommended without having attended Hydraulic Engineering (101-0206-00L) previously since Hydraulic Engineering II is strongly based on Hydraulic Engineering (101-0206-00L).

Hydraulic structures II
Information: Enrolment of Hydraulic Engineering II is not recommended without having attended Hydraulic Engineering (101-0206-00L) previously since Hydraulic Engineering II is strongly based on Hydraulic Engineering (101-0206-00L).

Hydraulic Structures II
Information: Because Hydraulic Structures II is strongly based on Hydraulic Engineering (101-0206-00L) it is strongly recommended to have taken this course (101-0206-00L) or a similar one previously.
The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river load. The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

### Lecture notes
Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0267-01L</td>
<td>Numerical Hydraulics</td>
<td>O 3</td>
<td>2G</td>
<td>M. Holzner</td>
</tr>
<tr>
<td>102-0455-01L</td>
<td>Groundwater I</td>
<td>W 4</td>
<td>3G</td>
<td>J. Jimenez-Martinez, M. Willmann</td>
</tr>
<tr>
<td>101-0258-00L</td>
<td>River Engineering</td>
<td>O 3</td>
<td>2G</td>
<td>V. Weitbrecht, I. Schalko, K. Sperger</td>
</tr>
<tr>
<td>102-0468-10L</td>
<td>Watershed Modelling</td>
<td>W 6</td>
<td>4G</td>
<td>P. Molnar</td>
</tr>
</tbody>
</table>

### Prerequisites / notice
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

### Taught competencies

<table>
<thead>
<tr>
<th>Subject</th>
<th>Competency</th>
<th>Taught</th>
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</thead>
<tbody>
<tr>
<td>Conceptual</td>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Methodological</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Methodological</td>
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<td>assessed</td>
</tr>
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<td>Decision-making</td>
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<tr>
<td>Methodological</td>
<td>Problem-solving</td>
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</tr>
<tr>
<td>Social</td>
<td>Communication</td>
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</tr>
<tr>
<td>Social</td>
<td>Cooperation and Teamwork</td>
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</tr>
<tr>
<td>Personal</td>
<td>Creative Thinking</td>
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</tr>
<tr>
<td>Personal</td>
<td>Critical Thinking</td>
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</tr>
<tr>
<td>Personal</td>
<td>Self-direction and Self-management</td>
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</tr>
</tbody>
</table>

Data: 18.08.2022 12:39
Autumn Semester 2022
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Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature consists of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

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

Method-specific Competencies
- Communication
- Cooperation and Teamwork

Social Competencies
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Personal Competencies

101-0250-00L Solving Partial Differential Equations in Parallel on GPUs

This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn about the diffusion process and how to solve it;
- Understand the practical challenges of parallel and distributed computing: (multi-)GPUs, multi-core CPUs;
- Learn about software development tools: git, version control, continuous integration (CI), unit tests.

Part 2 - Developing your own parallel algorithms
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Implement efficient iterative algorithms;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPUs);
- Learn about main simulation performance limiters.

Part 3 - Final project
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Links to relevant literature will be provided during classes.

Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

### Major in Materials and Mechanics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0677-00L</td>
<td>Concrete Technology</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>F. Constandopoulos, M. Bäuml, G. Martinola, T. Wangler</td>
</tr>
</tbody>
</table>

Opportunities and limitations of concrete technology. Commodities and leading edge specialties. Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.
Content
Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:
- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as
  - self compacting concrete
  - fiber reinforced concrete
  - fast setting concrete
  - fair faced concrete
  - recycled concrete
- new research in digital fabrication with concrete

Lecture notes
Slides provided for download.

Taught competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies assessed</td>
<td></td>
</tr>
</tbody>
</table>

Method-specific Competencies
Problem-solving assessed

Social Competencies
Communication assessed

Cooperation and Teamwork assessed

Personal Competencies
Creative Thinking assessed

Critical Thinking assessed

151-8015-00L Moisture Transport in Porous Media
W 3 credits 2G J. Carmeliet, L. Fei, D. A. Strebel

Abstract
Moisture transport and related degradation processes in porous materials; experimental determination of moisture transport properties; theory and application of pore network model for two-phase transport in porous media; flow in cracked and deformable porous media.

Objective
- Basic knowledge of moisture transport and related degradation processes in porous materials
- Knowledge of experimental determination of moisture transport properties
- Knowledge of pore network model and application to two-phase invasion percolation simulation
- Application of knowledge to moisture transport in cracked materials and flow in deformable porous media

Content
1. Introduction
Moisture damage: problem statement, durability
Applications: building materials, soil science, geoscience

2. Moisture transport: theory and application
Description of moisture transport
Determination of moisture transport properties
Liquid transport in cracked materials, flow and transport in deformable porous media

3. Pore network model: theory and application
Single- and two-phase pore network model: quasi-static and dynamic
Exercise on quasi-static two-phase pore network model: invasion pattern, capillary pressure curve
Application of pore network model in two-phase transport

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Literature
All material is provided online via Moodle.

151-0353-00L Mechanics of Composite Materials
W 4 credits 2V+1U P. Ermanni, G. Pappas

Abstract
Focus is on laminated fibre reinforced polymer composites. The course treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

Objective
To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures made from fibre reinforced polymer composites, including elastic behaviour, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Content
The course is addressing following topics:
- Introduction
- Elastic anisotropy
-Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Variable stiffness structures

Lecture notes
Script, handouts, exercises and additional material are available in PDF-format on the CMASLab webpage resp on moodle.

https://moodle-app2.let.ethz.ch/course/view.php?id=2610

Literature
The lecture material is covered by the script and further literature is referenced in there.
## Taught competencies

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

## Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

## Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

## Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

## Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

## Content

### Advances in Building Materials

- 101-0617-01L
- **W** 4 credits 2G
- R. J. Flatt, I. Burgert

#### Abstract

The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

#### Objective

In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

#### Content

- Material selection
- Materials and sustainability 1
- Materials and sustainability 2
- Recyclability
- Material science of wood durability
- Material science of concrete durability
- Foams in construction and thermal insulation
- Sealants and adhesives in construction
- Coatings
- Flame retardants
- Future of wood – 1
- Future of wood – 2
- Future of concrete – 1
- Future of concrete – 2

### Computational Science Investigation for Material Mechanics

- 101-0617-02L
- **W** 4 credits 2S
- D. Kammer, F. Wittel

#### Abstract

Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

#### Objective

Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can often only be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

#### Content

1. Introduction to (numeric) forensic engineering
2. The nature of engineering problems (governing equations)
3. Numerical recipes for dealing with non-linear problems
4. Multi-field problems (HTM)
5. On the nature of failure - Physics of damage and fracture
6. Cracks and growth in structures (LEFM and beyond)
7. Introduction to metal plasticity
8. Damage and fracturing in heterogeneous materials
9. Mechanics of fatigue
10. Visco-elastic failure
11. Student -Project presentation

### Literature

- Will be provided during the lecture via moodle.
- Will be provided during the lecture.
A student after completing the course will have the understanding of the Project Management duties, responsibilities, actions and decisions.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
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<td>Integrity and Work Ethics</td>
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3. Semester

Major Courses

Major in Construction and Maintenance Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0549-00L</td>
<td>Selected Topics on Legal Aspects in Civil Engineering</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>H. Briner, D. Trümpy</td>
</tr>
</tbody>
</table>

Objective

Part 1: The students shall acquire basic knowledge of the public law concerning civil engineering: space management, conception of buildings, protection of the environment, procedures.

Part 2: The students shall acquire basic knowledge of the private law concerning civil engineering.

Content

Teil 1: Jede Lektion behandelt für ein bestimmtes Stadium des Projekts ein Thema des öffentlichen Baurechts wie Bau- und Zonenordnungen, Quarterpläne, Umweltverträglichkeitsprüfungen, Baubewilligungsverfahren etc.


Lecture notes

D. Trümpy: Folien zu den Grundzügen des schweizerischen Bauvertragsrechts, Haftungs- und Prozessrechts (Vorlesungsunterlage)

H. Briner: Tafeln zu den Grundzügen des öffentlichen Raumplanungs-, Bau- und Umweltrechts (Vorlesungsunterlage)

Literature

- Gauch Peter, Werkvertrag, 5. Auflage, Schulthess 2011
- Stöckli P./Siegenthaler Th. (Hrsg.) Die Planerverträge, Schulthess 2013

Prerequisites / notice

Die Teilnehmer sollen stets ein Exemplar der SIA-Norm 118, der SIA-LHO 103 sowie die Gesetzesausgaben von OR und ZGB bei sich haben.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>101-0587-00L</td>
<td>Workshop on Sustainable Building Certification</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>H. Briner, D. Trümpy</td>
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</tbody>
</table>

Abstract

Building labels are used to certify buildings and neighbourhoods in term of sustainability. Many different labels have been developed and can be used in Switzerland (LEED, DGNB, SNBS, Minergie, 2000-Watt-Sites). In this course the differences between the certification labels and its application on 3 emblematic case study buildings will be discussed.

Objective

After this course, the students are able to understand and use the different certification labels.

They have a clear view of what the labels take into consideration and what they don't.

Content

Three buildings case study will be presented.

Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECHO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

After this overall general presentation and in order to have a closer look to specific aspects of sustainability, students will work in groups and assess during one or two weeks this specific criteria on one of the case studies presented before. This practical hands on the label will end with a presentation and a discussion where we will highlight differences between the labels.

This alternance of working session on one specific criteria for one specific building followed by a group presentation and discussion to compare labels is repeated for the different focus point (operation energy, mobility, daylight, indoor air quality).

The slides from the presentations will be made available.

Lecture notes

All documents for certification labels as well as detail plans of the buildings will be available for the students.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0520-00L</td>
<td>Project Management: Project Execution to Closeout</td>
<td>W+</td>
<td>4</td>
<td>2G</td>
<td>J. J. Hoffman</td>
</tr>
</tbody>
</table>

Abstract

The course will give Engineering students a comprehensive overview and enduring understanding of the techniques, processes, tool and terminology to manage the Project Triangle (time, cost, Quality) and to organize, analyze, control and report a complex project from start of Project Execution to Project Completion. Responsibilities will be detailed in each phase of the execution.

Objective

A student after completing the course will have the understanding of the Project Management duties, responsibilities, actions and decisions to be done during the Execution phase of a complex project.

Content

Execution Phase of the Project

Engineering Management - Scope, EV Measurement, Reporting and Organization
Procurement and Transportation - Scope, EV Measurement, Reporting and Organization
Civil Construction and Erection - Scope, EV Measurement, Reporting and Organization
Financial Reporting and forecasting
Risk & Opportunity Identification Assessment and Quantification during Execution
Team Organization and Leadership
Risk and opportuninty identification and quantification
Contract Claims and Delays
Execution Quality
Environmental Health and safety during execution

Literature

Required and suggested reading will be uploaded on weakly basis.

Prerequisites / notice

Prerequisite for this course is course Project Management: Pre-Tender to Contract Execution number 101-0517-01 G, unless otherwise approved by the lecturer.

<table>
<thead>
<tr>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>101-0608-00L</td>
<td>Design-Integrated Life Cycle Assessment</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>G. Habert, A. Gallimshina</td>
</tr>
</tbody>
</table>
The course will follow two main objectives and a third optional objective, depending on the design projects the students' choose. At the end of the course, the students will:
1. know the methodology of LCA
2. be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation

The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand
The first six individual courses will follow the "lectures on demand" approach. Small "hands-on" exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:
1) LCA basic introduction
2) System boundaries, functional unit, end of life
3) Carbon budget and LCA benchmarks
4) BIM-LCA, available calculation tools and databases
5) Integrated analysis of environmental and cost assessment
6) Bio-based carbon storage

Part II: Project-based learning
In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:
1) Introduction to Rhinoceros 6 and 7
2) Introduction to grasshopper
3) Integrated assessment tools (ladybug tools)
4) Introduction to in-house grasshopper plugin for LCA analysis

As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

The students are expected to work out of class as well. The course time will be used by the teachers to answer project-specific questions.

The lecture series will be conducted in English and is aimed at students of master's programs, particularly the departments ARCH, BAUG, ITET, MAVT, MTEC and UWIS.

No lecture will be given during Seminar week.

101-0577-00L An Introduction to Sustainable Development in the Built Environment

Abstract
In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict. What does it mean for the built environment?

Objective
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content
The following topics give an overview of the themes that are to be worked on during the lecture.
- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

101-0527-10L Materials and Constructions W 3 credits 2G G. Habert, M. Posani

Abstract Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction.


Content Introduction Sustainable cement and concrete Earth construction Visit Steel and bamboo Timber construction Building physic and conventional insulation Bio-based insulation Finishing Reuse

重大主要课程

101-0329-00L Tunnelling III W 4 credits 2G G. Anagnostou, E. Pimentel, M. Ramoni

Abstract Deepen the knowledge on selected topics of underground construction as well as learning working out conceptual solutions of complex problems.

Objective Lecture: Deepen the knowledge on selected topics of underground construction. Exercises: Conceptual solutions of complex problems.


Lecture notes Autographieblätter

Literature Empfehlungen

Prerequisites / notice Prerequisite: BSc course “Tunnelling”, MSc courses “Tunnelling I” and “Tunnelling II”.

Taught competencies Subject-specific Competencies Concepts and Theories assessed Techniques and Technologies assessed Method-specific Competencies Analytical Competencies assessed Decision-making assessed Problem-solving assessed

101-0339-00L Environmental Geotechnics W 3 credits 2G M. Plötze

Abstract Introduction of basic knowledge about problems with contaminated sites, investigation of this sites, risque management, remediation and reclamation techniques as well as monitoring systems. Introduction in landfill design and engineering with focus on barrier- and drainage systems and lining materials, evaluation of geotechnical problems, e.g. stability.

Objective Introduction of basic knowledge about problems with contaminated sites, investigation of this sites, risque management, remediation and reclamation techniques as well as monitoring systems. Introduction in landfill design and engineering with focus on barrier- and drainage systems as well as lining materials, evaluation of geotechnical problems, e.g. stability. In the course “Environmental Geotechnics”, the competencies of process understanding, system understanding, concept development, and measurement methods are taught and examined.

Content Definition of contaminated sites, site investigation methods, historical research and technical investigation, risque assessment, contamination transport, remediation, clean-up and retaining techniques (e.g. bioremediation, incineration, retaining walls, pump-and-treat, permeable reactive barriers), monitoring, research projects and results

Prerequisites / notice excursion
Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

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

101-0367-00L Geotechnical Engineering in Transportation

Type: W
ECTS: 3 credits
Hours: 2G
Lecturer: D. Hauswirth

Abstract
Road design criteria, Technology of road construction materials, geotechnical testing methods in Laboratory and in situ, Planning, monitoring and interpretation of soil field tests, Soil classification for traffic construction, Compaction of road structures and dams, Frost characteristics of soil materials, soil stabilization

Objective
Aim of the course is to teach students the most important aspects of the road structure, its building and design methods. An essential part of the course is devoted to understand the influence of the in-situ conditions: soil, underground, climate, water, as well as of the characteristics of building materials and of road surface on the durability of the pavement.

Content
Road design criteria, Technology of road construction materials, geotechnical testing methods in Laboratory and in situ, Planning, monitoring and interpretation of soil field tests, Soil classification for traffic construction, Compaction of road structures and dams, Frost characteristics of soil materials, soil stabilization

Prerequisites / notice
In den Vorlesungen und Übungen werden verschiedene Demonstrationsmaterialien verwendet.

Voraussetzungen: Grundlagenkenntnisse in "Bodenmechanik/Grundbau" sowie in "Projektierung von Verkehrsanlagen"

Autumn Semester 2022
In this course the students will learn how to do performance-based seismic design of building structures. This is a project-based course. The students will, in parallel, acquire the basis knowledge about the seismic behavior and non-linear response modeling of structures, and apply this knowledge in a project focused on design of a new building structure.
After successfully completing this course, the students will be able to:

1. Model and explain the seismic behavior of new structures with moment frame, braced frame and shear wall structural systems.
2. Evaluate the performance of new structures under earthquake loading using modern risk-informed performance assessment methods and analysis tools.
3. Use the knowledge of nonlinear dynamic response of structures to interpret the design code provisions and apply it in seismic design of structural systems.
4. Successfully design such systems to achieve the performance objectives stipulated by the design codes.

Content

This course completes the series of courses on dynamic analysis and seismic design of structures at ETHZ. Building on the material covered in Structural Dynamics and Seismic Design of Structures I, the following advanced topics will be covered in this course: 1) behavior and non-linear response modeling of structural systems under earthquake excitation; 2) displacement-based inelastic design of new building structures; 3) seismic design of moment frame, braced frame and shear wall structures; These topics will be discussed from the standpoint of risk-informed performance-based seismic design.

Lecture notes

Moodle is used to manage the course learning material. These include the lecture presentations, additional reading, exercise problems and solutions, example models of structures in OpenSees system for earthquake engineering simulation, and example designs. Lectures are streamed and recorded using the ETH Video Portal.

Literature


Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering, Borzorgnia, Y. and Bertero, V. Eds., CRC Press, 2004

The electronic copies of the learning material will be uploaded to ILIAS and available through myStudies. The learning material includes:

- Lecture notes
- Reading material
- Exercise problems and solutions
- Example models of structures in OpenSees system for earthquake engineering simulation
- Example designs
- Lectures streamed and recorded using the ETH Video Portal

The course will cover the analysis and design of isolation systems to mitigate earthquakes and other forms of vibrations. The course will:

1. Introduction: Overview of seismic isolation; review of structural dynamics and earthquake engineering principles. Viscoelastic behavior.
2. Linear theory of seismic isolation
3. Types of seismic isolation devices - Modelling of seismic isolation devices – Nonlinear response analysis of seismically isolated structures in Matlab
4. Behavior of rubber isolators under shear and compression
5. Behavior of rubber isolators under bending
6. Buckling and stability of rubber isolators
7. Code provisions for seismically isolated buildings

Prerequisites / notice

Number of participants limited to 18. All students go on a waiting list. Final registration based on an application letter (information given in the first lecture). Priority will be given to students who completed Seismic Design of Structures I (101-0188-00 G) and are in the primary target group (majoring in Structural Engineering and/or doing project-based coursework for other majors).

101-0191-00L Seismic and Vibration Isolation W 2 credits 1G M. Vassiliou

Abstract

This course will cover the analysis and design of isolation systems to mitigate earthquakes and other forms of vibrations. The course will cover:

1. Conceptual basis of seismic isolation, seismic isolation types, mechanical characteristics of isolators.
3. Design approaches and code requirements

Objective

After successfully completing this course the students will be able to:

1. Understand the mechanics of and design isolator bearings.
2. Understand the dynamics of and design an isolated structure.

Content

1. Introduction: Overview of seismic isolation; review of structural dynamics and earthquake engineering principles. Viscoelastic behavior.
2. Linear theory of seismic isolation
3. Types of seismic isolation devices - Modelling of seismic isolation devices – Nonlinear response analysis of seismically isolated structures in Matlab
4. Behavior of rubber isolators under shear and compression
5. Behavior of rubber isolators under bending
6. Buckling and stability of rubber isolators
7. Code provisions for seismically isolated buildings

Lecture notes

The electronic copies of the learning material will be uploaded to ILIAS and available through myStudies. The learning material includes:

- Reading material
- Optional) exercise problems and solutions
Fatigue and Fracture in Materials and Structures

The goal of the course is to introduce the civil engineering students to Structural Design, which is understood as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects.

After successfully completing this course the students will be able to:

1. Critically question structural design concepts of historical and contemporary references
2. Use graphic statics and strut-and-tie models based on the Theory of Plasticity to describe the load bearing behavior of structures
3. Understand different construction technologies and have an awareness of their potential for structural design
4. Use contemporary digital tools for the design of structures in equilibrium
5. Design an appropriate structural system for a given design task taking into account architectural considerations

The goal of the course is to introduce the civil engineering students to Structural Design, which is understood as a discipline that relates structural behavior, construction technologies and architectural concepts. Hence, the course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects, in which the static and architectural aspects come together. The course is structured in two main parts, each developed in half of a semester: a mainly theoretical one (including the teaching of graphic statics) and a mainly applied one (focused on the interactive application of equilibrium modelling in the form of short workshops).

Design Project:

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

Graphic statics is a graphical method developed by Prof. Karl Culmann and firstly published in 1864 at ETH Zurich. In this approach to structural analysis and design, geometric construction techniques are used to visualize the relation between the geometry of a structure and the forces acting in and on it, represented by geometrically dependent form and force diagrams.

The course will firstly review the main principles of graphic statics through a series of frontal lectures and discuss the relationship to analytical statics. Graphic statics is then used as an operative tool to design structures in equilibrium based on the lower bound theorem of the Theory of Plasticity. Additionally, the course will introduce contemporary methodologies and tools (parametric CAD software) for the interactive application of equilibrium modelling in the form of short workshops. The students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

Design Project:

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students’ ability to integrate architectural considerations into their structural design.

Material and Structures

The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

In this course, the students will learn:

- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.

Theory:

Dynamics of Structures, Theory and Applications to Earthquake Engineering, 4th edition, Anil Chopra, Prentice Hall, 2017
Design of seismic isolated structures: from theory to practice, Farzad Naeim and James M. Kelly, John Wiley & Sons, 1999
Mechanics of rubber bearings for seismic and vibration isolation, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011

101-0157-01 Structural Dynamics and Vibration Problems course, or equivalent, or consent of the instructor. Students are expected to know basic modal analysis, elastic spectrum analysis and basic structural mechanics.

Literature

- "Faustformel Tragwerksentwurf" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2015, ISBN 978-3-421-04012-1)

101-0123-00L Structural Design

The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects.

After successfully completing this course the students will be able to:

1. Critically question structural design concepts of historical and contemporary references
2. Use graphic statics and strut-and-tie models based on the Theory of Plasticity to describe the load bearing behavior of structures
3. Understand different construction technologies and have an awareness of their potential for structural design
4. Use contemporary digital tools for the design of structures in equilibrium
5. Design an appropriate structural system for a given design task taking into account architectural considerations

The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects, in which the static and architectural aspects come together. The course is structured in two main parts, each developed in half of a semester: a mainly theoretical one (including the teaching of graphic statics) and a mainly applied one (focused on the interactive application of equilibrium modelling in the form of short workshops).

Design Project:

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

Theory:

Graphic statics is a graphical method developed by Prof. Karl Culmann and firstly published in 1864 at ETH Zurich. In this approach to structural analysis and design, geometric construction techniques are used to visualize the relation between the geometry of a structure and the forces acting in and on it, represented by geometrically dependent form and force diagrams.

The course will firstly review the main principles of graphic statics through a series of frontal lectures and discuss the relationship to analytical statics. Graphic statics is then used as an operative tool to design structures in equilibrium based on the lower bound theorem of the Theory of Plasticity. Additionally, the course will introduce contemporary methodologies and tools (parametric CAD software) for the interactive application of equilibrium modelling in the form of short workshops. The students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

Design Project:

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students’ ability to integrate architectural considerations into their structural design.

Material and Structures

The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

In this course, the students will learn:

- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

Theory:

Dynamics of Structures, Theory and Applications to Earthquake Engineering, 4th edition, Anil Chopra, Prentice Hall, 2017
Design of seismic isolated structures: from theory to practice, Farzad Naeim and James M. Kelly, John Wiley & Sons, 1999
Mechanics of rubber bearings for seismic and vibration isolation, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011

101-0157-01 Structural Dynamics and Vibration Problems course, or equivalent, or consent of the instructor. Students are expected to know basic modal analysis, elastic spectrum analysis and basic structural mechanics.

Literature

- "Faustformel Tragwerksentwurf" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2015, ISBN 978-3-421-04012-1)
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Linear elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and "Laboratory Competition". The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- "Laboratory Competition" at Empa: the students with the closest predictions will win the "Empa Laboratory Competition" and will be awarded by a prize.

Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

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<tr>
<th>Prerequisites / notice</th>
<th>Objective</th>
<th>Lecture notes</th>
<th>Literature</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0169-00L</td>
<td>Timber Structures III</td>
<td>Students who have not completed Holzbau I require a special permission from the lecturer.</td>
<td>Lecture notes based on the lecture slides and the handouts, which will be given to the students during the semester.</td>
<td>Consolidation and supplementation of the basic knowledge acquired in Timber Structures I + II. Treatment of current topics and innovations in timber engineering. Structural design and refurbishment of complex timber structures with high requirements for earthquake resistance, sound insulation and fire protection. Description, analysis and discussion of an existing timber structure in groups.</td>
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<tr>
<td>101-0120-00L</td>
<td>Structural Glass Design and Facade Engineering</td>
<td>The course gives an introduction to structural glass design and related façade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.</td>
<td>Copies of lecture slides; Autography Timber Structures</td>
<td>After successful completion of the course, students will be able to:</td>
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<td>Swiss Standard SIA 265</td>
<td>- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;</td>
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<td></td>
<td>Swiss Standard SIA 265/1</td>
<td>- Recognize requirements for glass elements depending on their application area and chose the appropriate glass products and assemblies accordingly;</td>
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<td></td>
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<td></td>
<td>Eurocode 5</td>
<td>- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;</td>
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<td>- Apply selected approaches for the structural design of in-plane loaded glass elements;</td>
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<td>- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.</td>
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This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

**Lectures:**
The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent facades.

**Design exercises:**
The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJa Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

### Prerequisites

Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

### Literature


### Prerequisites / notice

- Requirements and functions for transparent facades.
- Familiarity with MATLAB and / or Python is advised.

### Major in Transport Systems

#### Content

This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

- Upon completion of the course, the students will be able to:
  1. understand main ML background theory and methods
  2. assess a problem and apply ML and DL in a computational framework accordingly
  3. Incorporating scientific domain knowledge in the SciML process
  4. Define, Plan, Conduct and Present a SciML project

#### Abstract

This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

#### Objective

A comprehensive series of computer / lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

#### Lecture notes

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

#### Literature

Suggested Reading:
- Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016

Familiarity with MATLAB and / or Python is advised.

### Design project

The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

### Lectures:

The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent facades.

### Design exercises:

The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJa Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

### Prerequisites

Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.
Methodology of Planning Research and Practice  

W  3 credits  2G  

A. Peric Momcilovic, T. Hug, R. Streit

103-0417-02L

Does not take place this semester. Only for master students, otherwise a special permission by the lecturer is required.

Abstract

This course deals with scientific and applied methods and the ways of thinking that are useful in planning practice as well as in scientific research. Students are offered interdisciplinary knowledge from planning practice and research, behavioural economics and social sciences. New perspectives on planning are opened up, which can lead to better results in future projects and research.

Objective

Keeping the general aim of exploring the basic methodologies in spatial planning research and practice, the specific course learning objectives are as follows:

- to address complex real-world spatial problems in adequate ways
- to know relevant theories and maxims that are subject to specific methods of problem solving
- to identify key questions and key concepts in contemporary planning research
- to select appropriate research methods to properly address the research questions

In practical terms, students:
- learn to deal with uncertainties and estimate quantities
- improve their ability to take decisions based on incomplete data and information
- are informed about different (qualitative and quantitative) methods and techniques for spatial research
- learn about different types of research (theoretical, empirical, action-oriented, qualitative, quantitative)
- get skilled for writing simple research essays
- are urged to question their own knowledge and challenge the course of action taken in planning processes

Content

The course is based on the following questions:

How do we deal with complex issues in planning?
- Forms of knowledge, half-knowledge and not knowing
- Occurrence and explanation patterns for irrational behaviour
- Spatial research and planning practice
- Planning maxims
- Mapping complex topics in research questions

How do we generate knowledge about complex issues?
- Methods for scientific data generation
- Applied handling of quantities and probabilities
- Estimating despite uncertainties
- Opportunities of digitisation in planning (Participation, BigData)

How do we react to complex questions in planning?
- Methods of scientific data analysis
- Making decisions despite incomplete information
- Dealing with robustness and fragility

More specifically, the lectures focus on the following topics (NB: Some content units will be presented in English, they are marked with *asterisk below)

- (Half-) knowledge/behaviour/irrationailities
- Initial situation: Solving complex problems
- Forms of knowledge, knowing of not knowing something, not knowing of not knowing something
- Behavioural patterns, occurrence and explanation patterns for irrational behaviour
- Methods for solving complex tasks in planning practice
- Spatial research and planning practice - connections, differences, overlaps
- Challenges in the solution of complex tasks: System delimitation, interdisciplinarity, retrospective vs. prospective approach (descriptive vs. action-oriented, *reflected scenario building*)
- Planning maxims
- *Methodology in spatial research
  *Research design
  *Research questions (types of research questions; research questions, hypotheses and theories); justification of research question
  Data generation methods (interviews and questionnaires, ethnography and observation, documents, official statistics)
  - Dealing with quantities, estimations, anchor effect
  - Importance of scales and key figures in planning
  - Estimation methods
  - Danger of the anchor effect
  - Digitization in planning
  - New data sources and sizes
  - Opportunities and challenges through digitisation in planning
  - Data analysis methods (quantitative and qualitative data; quantitative analysis of survey data; qualitative analysis - content analysis, discourse analysis, case study, comparative research)
  - *Research ethics
  - Decisions based on incomplete information
  - Dealing with complex systems/roughness
  *Role of science in planning - the perspective of both research and practice

Lecture notes

Learning materials: available online (Moodle) before corresponding lecture.

Literature

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

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

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

101-0491-00L Agent Based Modeling in Transportation

W 6 credits 4G M. Balac

Abstract
This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

Objective
At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform practical transportation studies

Content
This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open-source eqasim framework used at ETH Zurich to set up agent-based models will be introduced
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

Literature
Agent-based modeling in general

MATSim

Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

Prerequisites / notice
There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

101-0492-00L Microscopic Modelling and Simulation of Traffic Operations

W 3 credits 2G M. Makridis

Operations
The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.

Objective
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.
**Content**

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:
1. Car following models
2. Lane change models
3. Calibration and validation methodology

Specific tasks for the project will include:
1. Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2. Calibration and validating the simulation model.
3. Redesigning/extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students.

It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

**Lecture notes**
The lecture notes and additional handouts will be provided before the lectures.

**Literature**
Additional literature recommendations will be provided at the lectures.

**Prerequisites / notice**
Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

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**Content**

Geotechnical Engineering in Transportation

**Abstract**

Road design criteria, Technology of road construction materials, geotechnical testing methods in Laboratory and in situ, Planning, monitoring and interpretation of soil field tests, Soil classification for traffic construction, Compaction of road structures and dams, Frost characteristics of soil materials, soil stabilization

**Objective**

Aim of the course is to teach students the most important aspects of the road structure, its building and design methods. An essential part of the course is devoted to understand the influence of the insitu conditions: soil, underground, climate, water, as well as of the characteristics of building materials and of road surface on the durability of the pavement.

**Content**

Road design criteria, Technology of road construction materials, geotechnical testing methods in Laboratory and in situ, Planning, monitoring and interpretation of soil field tests, Soil classification for traffic construction, Compaction of road structures and dams, Frost characteristics of soil materials, soil stabilization

**Lecture notes**

Autographie, Uebungsblätter, Handouts, Folien

**Literature**

As indicated in the course

Voraussetzungen: Grundlagenkenntnisse in "Bodenmechanik/Grundbau" sowie in "Projektierung von Verkehrsanlagen"

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**Content**

Railway Infrastructures 2

**Abstract**

Track geometry including calculation and measuring as well as related data systems; clearance profiles; interaction between track and vehicles; vehicle dynamics, stress; track construction including special features of railway bridges and tunnels; environmental aspects in track construction; track diagnostics and forecast; track maintenance and related methods

**Objective**

The lecture gives a deeper insight into track geometry including clearance profile, the interaction between track and vehicles as well as in construction and dimensioning of the track. Methods for the diagnosis of the state of the track and its forecast are shown. State-of-the-art maintenance strategies and technologies are presented.

**Content**

1. Track geometry
   Track geometry including calculation and measuring as well as related data systems; clearance profiles

2. Interaction
   Interaction between track and vehicles, vehicle dynamics

3. Railway Track
   Stress; track construction including special features of railway bridges and tunnels

4. Environmental aspects in track construction
   Fundamentals; noise protection; vibration protection

5. Diagnostics, maintenance strategies
   Track diagnostics and forecast; maintenance strategies

6. Track maintenance
   Fundamentals of track maintenance and related methods

**Lecture notes**

The slides will be made available.

**Literature**


**Prerequisites / notice**

A list with related technical literature will be handed out.

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**Content**

Basics of Java and Best Practices for Scientific Computing

**Abstract**

This course provides an introduction to programming in Java, version control, and cloud computing.

**Objective**

At the end of the course, the students should
- Have acquired object-oriented programming skills with a focus on Java.
- Have an understanding of version control using git
- Have learned to deploy java applications on servers

**Content**

This course provides an introduction to object-oriented programming with Java. Four topics are covered:
- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...)
- Injection (traditional vs. Guice)
- Code versioning
- Java application deployment on servers

**Literature**

Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
101-0367-00L | Geotechnical Engineering in Transportation | W | 3 credits | 2G | D. Hauswirth
101-0419-02L | Railway Infrastructures 2 | W | 2 credits | 2G | U. A. Weidmann, P. Güldenapfel, M. Kohler, M. J. Manhart
101-0491-10L | Basics of Java and Best Practices for Scientific Computing | W | 1 credit | 1U | M. Balac

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## 101-0249-00L | Hydraulic Engineering: Selected Topics

**W 3 credits 2S R. Boes**

*Does not take place this semester.*

**Prerequisites:** 101-0247-01L Hydraulic Engineering II or equivalent course.

### Abstract
The lecture focuses on selected topics in hydraulic engineering, water management and aquatic ecology relating to hydropower and flood protection projects.

### Objective
The overarching goal of the course is to deepen knowledge on special aspects in hydraulic engineering and to understand the procedures and the planning sequence of hydropower projects.

### Content
Different selected topics in hydraulic engineering will be focused on, e.g. dam safety, materials in dam building, possible problems at reservoirs like natural hazards by impulse waves, the hydraulics of spillways and intake structures at dams and weirs and the area of conflict between hydropower and ecology. Another focus will be put on typical approaches and procedures in the planning process of hydropower projects at the national and international level.

### Lecture notes
Lecture notes will be available online.

### Literature
External speakers will be involved to present current topics and projects in Switzerland and abroad.

### Taught competencies

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### 101-0289-00L | Applied Glaciology

**W 4 credits 2G D. Farinotti, A. Bauder, M. Werder**

### Abstract
The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

### Objective
The objectives of the course are to:
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

### Content
The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glacier and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

### Lecture notes
Digital lecture handouts will be distributed prior to each class.

### Literature
Links to relevant literature will be provided during the classes.

### Prerequisites / notice
Completed BSc studies. Basic knowledge in computer scripting in any language (e.g. Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.

### Taught competencies

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### 101-1249-00L | Hydraulics of Engineering Structures

**W 3 credits 2G I. Albayrak, F. Evers**

### Abstract
Hydraulic fundamentals are applied to hydraulic structures for wastewater, flood protection and hydropower. Typical case studies from engineering practice are further described.

### Objective
Understanding and quantification of fundamental hydraulic processes with particular focus on hydraulic structures for wastewater, flood protection and hydropower.

In the course "Hydraulics of Engineering Structures", the competencies of process understanding, system understanding and measurement methods are taught, applied and examined. The competencies of modeling, concept development and data analysis & interpretation are taught and data analysis & interpretation is applied in addition.
Content
1. Introduction & Basic equations
2. Losses in flow & Maximum discharge
3. Uniform flow & Critical flow
4. Hydraulic jump & Stilling basin
5. Backwater curves
6. Weirs & End overfall
7. Sidewir & Side channel
8. Bottom opening, Venturi & Culverts, Restrictors, Inverted siphons
9. Fall manholes & Vortex drop
10. Supercritical flow & Special manholes
11. Aerated flows & Low level outlets
12. Hydraulics of sediment bypass tunnels
13. Vegetated flows - Introduction & Application
14. Summary

Lecture notes
Text books


Literature
Exhaustive references are contained in the suggested text book.

102-0215-00L Urban Water Management II W 4 credits 2G M. Maurer, P. Staufer

Abstract

Objective
Consolidation of the basic procedures for design and operation of technical networks in water engineering.

Content
Demand Side Management versus Supply Side Management
Optimierung von Wasservereinteinnetzen
Kalkausfällung, Korrosion von Leitungen
Hygiene in Verteilsystemen
Siedlungshydrologie: Niederschlag, Abflussbildung
Instationäre Strömungen in Kanalisationen
Stofftransport in der Kanalisation
Einleitbedingungen bei Regenwetter
Versickerung von Regenwasser
Generelle Entwässerungsplanung (GEP)

Lecture notes
Written material will be available digital.

Prerequisites / notice
Prerequisite: Introduction to Urban Water Management

Taught competencies

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

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed

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

101-1250-00L Management of Hillslope and Channel Processes W 3 credits 2V D. Rickenmann

Abstract

Objective
Ziel
To recognise and understand channel and hillslope processes and their interactions. To learn about methods of hazard analysis and of technical and bioengineering protection measures and their assessment. Determination of critical loads and design of protective structures. Assessment of spatial and future developments with and without protective measures.

Content
Inhalt

Lecture notes
see "Literatur"

Literature
Prerequisites / notice
Besonderes
Requirements:
- Essentials of Construction Analysis
- Hydraulics
- Geology and Petrography
- Soil Physics
- Soil Mechanics and Geotechnics

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

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

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

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

Media and Digital Technologies not assessed
Problem-solving assessed

Concepts and Theories assessed

 社科性能

- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork not assessed
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- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
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Personal Competencies
- Adaptability and Flexibility not assessed
- Creative Thinking not assessed
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Major in Materials and Mechanics

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<tr>
<td>101-0539-01L</td>
<td>Science and Engineering of Glass and Natural Stone in Construction</td>
<td>W</td>
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Does not take place this semester.

Abstract
The course offers an overview of relevant practical issues and present technological challenges for glass and natural stones in constructions. Students gain a good knowledge of the basics of glasses and natural stones, their potential as engineering materials and learn to apply them in the design of civil engineering constructions and to evaluate concepts.

Objective
Glass is increasingly used in constructions to ease the construction process, as functional insulation barrier, even for structural applications of impressive size. While everyone has experienced the innovation potential of glass in the last decade, products from natural stone suffer from an unjustified traditional image that often originates from a lack of understanding of the material and its combination with other materials. Culturally important structures often are made from natural stone and their conservation demands an understanding of their deterioration mechanisms, the concepts of which can be applied to other civil engineering materials. Designers and engineers need the knowledge to reconcile materials and system behavior with the entire processing, handling, integration and life time in mind.

In this module students are provided with a broad fundamental as well as practice-oriented education on glass and natural stone in civil engineering applications. Present and future construction and building concepts demand for such materials with optimized properties. Based on the fundamentals from the Bachelor course in materials by the end of this module, you should be able to:

- recognize and choose specific applications from the broad overview you were provided with,
- relate processing technologies to typical products and building applications and recognize (and explain typical damage related to wrong material choice or application,
- explain the nature of glassy and crystalline materials and interpret their physical behavior against this background,
- explain the major deterioration mechanisms in natural stone and how this relates to durability,
- analyze material combinations and appraise their application in future products as well as integration in existing constructions,
- summarize with appropriate guidance publications on a related topic in an oral presentation and short report.
Lecture 1: An introduction to science and engineering of glass and natural stone in construction (FW/TW)

Lecture 2: Glass chemistry including historical development of glass composition, use of raw materials, melts, chemical stability and corrosion. (FW)

Lecture 3: Geology and mineralogy of stones used in construction. Formation processes, chemistry, crystal structure. (TW)

Lecture 4: Microscopic models for glassy materials. Physics of vitrification. From microscopic physical models to thermodynamics, rheology and mechanics of glassy materials. (FW)

Lecture 5: Stone properties and behavior: microstructure, density, porosity, mechanical properties (TW)

Lecture 6: Glass physics: Optical properties (transmission, reflection, emission, refraction, polarization and birefringence, testing methods); Mechanical properties (density, thermal, mechanical, electric properties, glass testing) (FW)

Lecture 7: Stone properties and durability: transport, moisture and thermal cycling (TW)

Lecture 8: Forming and processing of glass: (plate and molded glass, drawing, slumping, profiling etc.; Processing: Cutting, mechanical processing, tempering, gluing, bending, laminating of glass Surface treatments: coating, sputtering, enameling, printing, etching, chemical pre-stressing.) (FW)

Lecture 9: Durability: Salt crystallization, freezing, biodeterioration (TW)

Lecture 10: Glass products for civil engineering applications: (Molded glasses, fiber glass, foam glass, plate glass); construction glass (insulation glass, structural glass, protective glass, intelligent glass, codes); (FW)

Lecture 11: Conservation: Consolidation, cleaning, and other treatments (TW).

Lecture 12: Glass in constructions. (modeling, application and regulation, typical damage in glass) (FW)

Lecture 13: Student presentations; exam questions (FW/TW)

Lab1: Durability of natural stone (FW/TW)

Lab2: Fracture of glass (FW/TW)

Literature

Werkstoffe II script (download via the IFB homepage). Rest will be handed out in the lectures

Prerequisites / notice

Werkstoffe I/II of the bachelor studies or equivalent introductory materials lecture.

Taught competencies

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<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

101-0659-01L Durability and Maintenance of Reinforced Concrete W 4 credits 2V U. Angst, Z. Zhang

Abstract

We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.

Objective

After this course you will have profound understanding about:
- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:
- current engineering approaches for durability design (according to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- preventive measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies
Content

- Socio-economic challenges related to ageing infrastructures
- Degradation mechanisms for concrete: sulphate attack, ASR, frost attack.
- Inspection and condition assessment: Chloride analyses, carbonation depth, etc. Non-destructive tests, particularly potential mapping to detect corrosion. New developments (for example, monitoring with sensors).
- Stainless steel as reinforcing steel for concrete: Different types of stainless steels. Coupling with black reinforcing steel. Examples of application. Life-cycle-costs.
- Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

Excursion:

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Lecture notes

The course is based on the book


Slides of the lectures will be distributed in advance

Special handouts and reprints for particular topics will be distributed

Literature


Slides of the lectures will be distributed in advance

Prerequisites / notice

Form of teaching:

The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Report:

Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:

We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Taught competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

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

101-0689-00L Shrinkage and Cracking of Concrete: Mechanisms and Impact on Durability

W 3 credits 2V P. Lura, M. Wyrzykowski

Abstract

Concrete is generally viewed as a durable construction material. However, the long-term performance of a concrete structure can be greatly compromised by early-age cracking. This course will explain how shrinkage of concrete leads to cracking and how control of shrinkage allows increasing the expected durability of a concrete structure.

Objective

This course will begin with a brief introduction about hydration and microstructure development in cement paste and concrete. The students will learn the main causes of cracking at early ages, namely plastic, drying, thermal and autogenous shrinkage, with special emphasis on the driving mechanisms. The importance of concrete curing, especially in the first few days after casting, will be stressed and explained. Building on the knowledge of the driving forces of shrinkage, the way of action of shrinkage-reducing admixtures will be clarified and different applications illustrated. As an extension of external curing, the students will become familiar with internal water curing by means of saturated lightweight aggregates and superabsorbent polymers.

Most concrete members are restrained by adjacent structures. When shrinkage is restrained, cracks may develop. The students will learn how to apply different criteria for assessing concrete cracking and how to retrieve the mechanical properties of the concrete, especially stiffness and creep, which are needed for the calculations of self-induced stresses and risk of cracking.

In addition to macroscopic cracks, microcracking may occur in the cement paste due to inner restraint offered by the aggregates. Both macroscopic cracks and diffuse microcracking within a concrete may facilitate the ingress of harmful substances (e.g. chloride and sulfate ions) into the concrete; these may react with the concrete or with the reinforcement and create further deterioration. The students will acquire an understanding of the mechanisms of transport through cracked concrete, with special focus on experimental evidence and on techniques able to visualize the transport process and follow it in time.

As a final outcome of the course, the students will be able to estimate the impact of cracking on the expected durability of concrete structures and to implement different types of measures to reduce the extent of cracking.
Concrete is generally viewed as a long-lasting construction material. However, the durability of a concrete structure can be jeopardized by shrinkage-induced cracking. In addition to being unsightly, cracks have the potential to act as weak planes for further distress or as conduits for accelerated ingress of aggressive agents that may reduce durability.

Advances in concrete technology over the past decades have led to the practical use of concrete with a low water to binder ratio and with different types of mineral and organic admixtures. Another recent development is self-compacting concrete, which avoids concrete vibration and reduces labor during placing. Unfortunately, these concretes are especially prone to cracking at early ages, unless special precautions are taken. Proper curing becomes in this case the key to achieve better performance in various environmental and load conditions.

Specific topics covered by the course:
- Hydration and microstructure development
- Plastic shrinkage
- Development of mechanical properties
- Thermal deformation
- Autogenous deformation
- Drying shrinkage
- Creep and relaxation
- Curing
- Shrinkage-reducing admixtures
- Internal curing: saturated lightweight aggregates and superabsorbent polymers
- Fracture and microcracking
- Transport in cracked concrete
- Impact of cracking on concrete durability
- Self-healing of cracks
## Literature

Useful (optional) Reading:

## Prerequisites / Notice

Prerequisites:
- 101-0158-01 Method of Finite Elements I (FS)

A good knowledge of Python is necessary for attending this course.

## Taught Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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</table>

## Projects

### Number | Title | Type | ECTS | Hours | Lecturers |
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<tr>
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<tbody>
<tr>
<td>101-0198-10L</td>
<td>Project on Construction Engineering</td>
<td>W</td>
<td>11 credits</td>
<td>24A</td>
<td>Supervisors</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Working on a concrete task in Construction Engineering</td>
<td></td>
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<tr>
<td><strong>Objective</strong></td>
<td>Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The project work is supervised by a professor. Students can choose from different subjects and tasks.</td>
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</table>

### 101-0298-10L | Project on Hydraulic Engineering and Water Resources Management | W | 11 credits | 24A | Supervisors |

### 101-0398-10L | Project on Geotechnical Engineering | W | 11 credits | 24A | Supervisors |

### 101-0498-10L | Project on Transport Systems | W | 11 credits | 24A | Supervisors |

### 101-0598-10L | Project on Construction and Maintenance Management | W | 11 credits | 24A | Supervisors |

### 101-0698-10L | Project on Materials and Mechanics | W | 11 credits | 24A | Supervisors |

## Digitalisation Specific Courses

### Number | Title | Type | ECTS | Hours | Lecturers |
<table>
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<tr>
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<tbody>
<tr>
<td>101-0317-00L</td>
<td>Tunnelling I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Anagnostou, A. Nordas, E. Pimentel</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.</td>
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The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems.

Fundamentals of traffic flow theory and control.

Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

Numerical analysis methods in tunnelling.

Decision-making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FORM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>G</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>101-0187-00L</td>
<td>Structural Reliability and Risk Analysis</td>
<td>W</td>
<td>3</td>
<td>S. Marelli</td>
</tr>
<tr>
<td>101-0437-00L</td>
<td>Traffic Engineering</td>
<td>W</td>
<td>6</td>
<td>S. Mousavi, A. Kouvelas, M. Makridis</td>
</tr>
<tr>
<td>101-0417-00L</td>
<td>Transport Planning Methods</td>
<td>W</td>
<td>6</td>
<td>K. W. Axhausen</td>
</tr>
</tbody>
</table>
The course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

At the end of the course, the students should:
1) have an understanding of agent-based modeling
2) have an understanding of MATSim
3) have an understanding of the process needed to set up an agent-based study
4) have practical experience of using MATSim to perform practical transportation studies

This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.
This class overviews advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to excessive loading effects and energy dissipation mechanisms. Their understanding is necessary for reliably computing structural capacity. In this course, instead of blindly using generic structural analysis software, we offer an explicit understanding of what goes on behind the curtains, by explaining the algorithms that are used in such software.

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems.

See the class webpage for more information:

Lecture notes
The course slides serve as Script. These are openly available on: http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

Useful (optional) Reading:

Prerequisites / notice
-101-0158-01 Method of Finite Elements I (FS)
- A good knowledge of Python is necessary for attending this course.

Taught competencies

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Computational Science Investigation for Material Mechanics

Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various models. This course specifically covers the treatment of the following phenomena:

1. Introduction to (numeric) forensic engineering
2. The nature of engineering problems (governing equations)
3. Numerical recipes for dealing with non-linear problems
4. Multi-field problems (HTM)
5. On the nature of failure - Physics of damage and fracture
6. Cracks and growth in structures (LEFM and beyond)
7. Introduction to metal plasticity
8. Damage and fracture in heterogeneous materials
9. Mechanics of fatigue
10. Visco-elastic failure
11. Student - Project presentation

Lecture notes
Will be provided during the lecture via moodle.

Literature
Will be provided during the lecture.

<table>
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Introduction to computer aided design and drafting in 2D and 3D with examples from structural engineering

Prerequisites:
-101-0158-01 Method of Finite Elements I (FS)

Point in time of enrolment of course is decisive.

Number of participants is limited to 30.

F. Ortize Quintana, M. Miani

Autumn Semester 2022
Objective
Having followed the course, students are able to:
- develop a 2D-structure (formwork drawing) and they know the principle of a 3D reinforcement module.
- There have also got an introduction to a 3D program (reinforcement in 3D).
- They are therefore better prepared for:
  - the bachelor thesis in the 6th semester,
  - an eventual internship between bachelor and master course,
  - the project works in the master course,
  - the master thesis.
Above all, they practice spatial sense and acquire contextual knowledge as future superior draftsman and designers.

Lecture notes
CAD für Bauingenieure
Spezialbewilligung der Dozierenden notwendig.
Arbeit ausschliesslich am eigenen Laptop. Die rechtzeitige Installation der Software ist Bedingung für die Teilnahme. Eine Anleitung zur Installation wird ausgegeben.

Prerequisites / notice
Spezialbewilligung der Dozierenden notwendig.
Arbeit ausschliesslich am eigenen Laptop. Die rechtzeitige Installation der Software ist Bedingung für die Teilnahme. Eine Anleitung zur Installation wird ausgegeben.

101-0250-00L Solving Partial Differential Equations in Parallel on GPUs

Abstract
This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

Objective
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require efficient algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve problems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Content
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn about the diffusion process and how to solve it;
- Understand the practical challenges of parallel and distributed computing: (multi-)GPUs, multi-core CPUs;
- Learn about software development tools: git, version control, continuous integration (CI), unit tests.

Part 2 - Developing your own parallel algorithms
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Implement efficient iterative algorithms;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPUs);
- Learn about main simulation performance limiters.

Part 3 - Final project
- Apply your new skills in a final project:
  - Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

101-0139-00L Scientific Machine and Deep Learning for Design and Construction in Civil Engineering

Abstract
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

Objective
Upon completion of the course, the students will be able to:
1. understand main ML background theory and methods
2. assess a problem and apply ML and DL in a computational framework accordingly
3. Incorporating scientific domain knowledge in the SciML process
4. Define, Plan, Conduct and Present a SciML project

Content
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

Lecture notes
The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Literature
Suggested Reading:
Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016
O. Martin: Bayesian analysis with python. Packt Publishing Ltd, 2016

Prerequisites / notice
Familiarity with MATLAB and / or Python is advised.

101-0120-00L Structural Glass Design and Facade Engineering

Abstract
The course gives an introduction to structural glass design and related façade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.
Objective

After successful completion of the course, students will be able to:

- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and choose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Apply selected approaches for the structural design of in-plane loaded glass elements;
- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.

Content

This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:

- Production, Properties and Properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulated glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent facades.

Design exercises:
The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Lecture notes

The lectures are based on lecture slides and handouts.

Literature

Recommended and supplementary literature:


Prerequisites / notice

Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.
The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.

2. Positioning infrastructure management in society. As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.

3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.

4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This week we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.

5. Help session 1

6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.

7. Determining and justifying monitoring - Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.

8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.

9. Help session 2

10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.

11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.

12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.

13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.

14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

The lecture materials will be distributed via Moodle two days before each lecture. Appropriate literature will be handed out when required via Moodle.

This course has no prerequisites.

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

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

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

The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.
Objective
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with conceptual theories, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.
Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.
Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content
In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:
1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/extend the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and present) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour work in pairs on a group project that counts for 30% of the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.
The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

101-0123-00L  Structural Design                  W  3 credits  2G  F. Bertagna, D. Tanadini, P. Block, P. Ohlbrock, J. Schwartz

Abstract
The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects.

Objective
After successfully completing this course the students will be able to:
1. Critically question structural design concept of historical and contemporary references
2. Use graphic statics and strut-and-tie models based on the Theory of Plasticity to describe the load bearing behavior of structures
3. Understand different construction technologies and have an awareness of their potential for structural design
4. Use contemporary digital tools for the design of structures in equilibrium
5. Design an appropriate structural system for a given design task taking into account architectural considerations

Content
The goal of the course is to introduce the civil engineering students to Structural Design, which is understood as a discipline that relates structural behavior, construction technologies and architectural concepts. Hence, the course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects, in which the static and architectural aspects come together. The course is structured in two main parts, each developed in half of a semester: a mainly theoretical one (including the teaching of graphic statics) and a mainly applied one (focused on the development of a design project by the students using digital form-finding tools).

Design Project:
Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students' ability to integrate architectural considerations into their structural design.

Literature
“Faustformel Tragwerkseinsatz”
(Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2015, ISBN 978-3-421-04012-1)

“Form and Forces: Designing Efficient, Expressive Structures”

“The art of structures, Introduction to the functioning of structures in architecture”

102-0468-10L  Watershed Modelling                  W  6 credits  4G  P. Molnar

Abstract
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).
Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

Content
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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101-0121-00L Fatigue and Fracture in Materials and Structures

W 4 credits 3G A. Taras

Does not take place this semester.

Abstract
The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

Objective
In this course, the students will learn:
- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

Content
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainfall analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- ELInear elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris’ law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and “Laboratory Competition”. The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- “Laboratory Competition” at Empa: the students with the closest predictions will win the “Empa Laboratory Competition” and will be awarded a prize.

Lecture notes
Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Literature
This course provides an introduction to programming in Java, version control, and cloud computing. 

Prerequisites / notice

Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

101-0491-10L Basics of Java and Best Practices for Scientific Computing

W 1 credit 1U M. Balac

Abstract

This course provides an introduction to programming in Java, version control, and cloud computing.

Objective

At the end of the course, the students should

- Have acquired object-oriented programming skills with a focus on Java.
- Have an understanding of version control using git
- Have learned to deploy Java applications on servers

Content

This course provides an introduction to object-oriented programming with Java. Four topics are covered:

- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...)
- Injection (traditional vs. Guice)
- Code versioning
- Java application deployment on servers

Literature

Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

Project Based Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>101-0509-00L</td>
<td>Infrastructure Management 1: Process</td>
<td>W</td>
<td>6 credits</td>
<td>2G</td>
<td>B. T. Adey</td>
</tr>
</tbody>
</table>

Abstract

Infrastructure asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods of time. This course provides an overview of the process, from setting goals to developing intervention programs to analyzing the process itself. It consists of weekly lectures and a group project. Additionally, there is a weekly help session.

Objective

There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines and much of the research, however, are focused on only part of the large complex problem of infrastructure asset management.

Content

The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.
2. Positioning infrastructure management in society: As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.
3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.
4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.
5. Help session 1
6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.
7. Determining and justifying monitoring - Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.
8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.
9. Help session 2
10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.
11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.
12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.
13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.
14. Help session 3 and submission of project report

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.
Lecture notes
- The lecture materials consist of handouts, the slides, and example calculations in Excel.
- The lecture materials will be distributed via Moodle two days before each lecture.

Literature
Appropriate literature will be handed out when required via Moodle.

Prerequisites / notice
This course has no prerequisites.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

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

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

101-0249-00L Hydraulic Engineering: Selected Topics

W 3 credits 2S R. Boes

Abstract
The lecture focuses on selected topics in hydraulic engineering, water management and aquatic ecology relating to hydropower and flood protection projects.

Objective
The overarching goal of the course is to deepen knowledge on special aspects in hydraulic engineering and to understand the procedures and the planning sequence of hydropower projects.

Content
Different selected topics in hydraulic engineering will be focused on, e.g. dam safety, materials in dam building, possible problems at reservoirs like natural hazards by impulse waves, the hydraulics of spillways and intake structures at dams and weirs and the area of conflict between hydropower and ecology. Another focus will be put on typical approaches and procedures in the planning process of hydropower projects at the national and international level.

Lecture notes
Lecture notes will be available online.

Literature

Prerequisites / notice
External speakers will be involved to present current topics and projects in Switzerland and abroad.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

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

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

101-0608-00L Design-Integrated Life Cycle Assessment

W 3 credits 2G G. Habert, A. Galimshina

Abstract
Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process.

The aim of this course is to apply LCA during the design of buildings by means of a digital, parametric tool. The necessary fundamentals of the LCA method will be taught following a lecture on demands approach.

Objective
The course will follow two main objectives and a third optional objective, depending on the design projects the students’ choose. At the end of the course, the students will:

1. Know the methodology of LCA
2. Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation
Content
The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand
The first six individual courses will follow the "lectures on demand" approach. Small "hands-on" exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:
1) LCA basic introduction
2) System boundaries, functional unit, end of life
3) Carbon budget and LCA benchmarks
4) Biomass-LCA, available calculation tools and databases
5) Integrated analysis of environmental and cost assessment
6) Bio-based carbon storage

Part II: Project-based learning
In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students' background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:
1) Introduction to Rhino 6 and 7
2) Introduction to grasshopper
3) Integrated assessment tools (Ladybug tools)
4) Introduction to in-house grasshopper plugin for LCA analysis

Lecture notes
As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

Prerequisites / notice
Prerequisite: Sustainable construction (101-0577-00L). Otherwise a special permission by the lecturer is required.

The students are expected to work out of class as well. The course time will be used by the teachers to answer project-specific questions.

The lecture series will be conducted in English and is aimed at students of master's programs, particularly the departments ARCH, BAUG, ITET, MAVT, MTEC and UWIS.

No lecture will be given during Seminar week.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>101-0329-00L</td>
<td>Tunnelling III</td>
<td>4</td>
<td>2G</td>
<td>Prerequisite: BSc course &quot;Tunnelling&quot;, MSc courses &quot;Tunnelling I&quot; and &quot;Tunnelling II&quot;</td>
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<td></td>
<td>Abstract: Deepen the knowledge on selected topics of underground construction as well as learning working out conceptual solutions of complex problems.</td>
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<tr>
<td></td>
<td>Objective: Lecture: Deepen the knowledge on selected topics of underground construction. Exercises: Conceptual solutions of complex problems.</td>
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<td>Lecture notes: Autographieblätter</td>
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<td>Literature: Empfehlungen</td>
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<tr>
<td>101-0200-10L</td>
<td>Research-Focused Project Work</td>
<td>11</td>
<td>4A</td>
<td>Supervisors</td>
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<td></td>
<td>Abstract: Working on a concrete task as preparation for the master’s thesis</td>
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<td></td>
<td>Objective: Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.</td>
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<td>Content: The project work is supervised by a professor. The topic is going to be continued as master’s thesis.</td>
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<tr>
<td>101-0139-00L</td>
<td>Scientific Machine and Deep Learning for Design and Construction in Civil Engineering</td>
<td>3</td>
<td>4G</td>
<td>M. A. Kraus, D. Griego, R. Rust</td>
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<tr>
<td></td>
<td>Abstract: This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.</td>
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<td>Objective: This course aims to provide graduate level introduction into Machine and especially scientific Machine Learning for applications in the design and construction phases of projects from civil engineering.</td>
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<td>Upon completion of the course, the students will be able to: 1. understand main ML background theory and methods 2. assess a problem and apply ML and DL in a computational framework accordingly 3. Incorporating scientific domain knowledge in the SciML process 4. Define, Plan, Conduct and Present a SciML project</td>
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<td>Content: The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment. The topics to be covered are: 1. Fundamentals of Machine and Deep Learning (ML / DL) 2. Incorporation of Domain Knowledge into ML and DL 3. ML training, validation and testing pipelines for academic and research projects</td>
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<td>A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a &quot;hands-on&quot; feel for the course topics.</td>
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<td>Lecture notes: The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.</td>
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</table>
After successful completion of the course, students will be able to:
- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and chose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Apply selected approaches for the structural design of in-plane loaded glass elements;
- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.
The course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent façades.

Design exercises:
The principles and methods presented in the lectures are practiced in the students with design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Prerequisites:
Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

Literature

Design project:
The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

Content
This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering. When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development. The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Abstract
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Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.
After this course you will have profound understanding about:

- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:

- current engineering approaches for durability design (according to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- preventive measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies

The course is based on the book

Communication

Opportunities and limitations of concrete technology.

Adaptability and Flexibility

After this course you will have profound understanding about:

- Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

- Stainless steel as reinforcing steel for concrete: Different types of stainless steels. Coupling with black reinforcing steel. Examples of application. Life-cycle-costs.
- Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

Excursion:

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

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Lecture notes

The course is based on the book


Special handouts and reprints for particular topics will be distributed

Report:

Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Prerequisites / notice

Form of teaching:

The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Report:

Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.
Content

Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as
  - self compacting concrete
  - fiber reinforced concrete
  - fast setting concrete
  - fair faced concrete
  - recycled concrete
- new research in digital fabrication with concrete

Lecture notes

Slides provided for download.

Taught competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Problem-solving

Social Competencies

Communication

Cooperation and Teamwork

Personal Competencies

Creative Thinking

Critical Thinking

101-0427-01L Public Transport Design and Operations W 6 credits 4G F. Corman, T.-H. Yan

Abstract

This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.

Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:

- general introduction of transport, modes, technologies,
- system design and line planning for different situations,
- mathematical models for design and line planning
- timetabling and tactical planning, and related mathematical approaches
- operations, and quantitative support to operational problems,
- evaluation of public transport systems.

Content

Basics for line transport systems and networks

Passenger/Supply requirements for line operations

Objectives of system and network planning, from different perspectives and users, design dilemmas

Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations

Matching demand and modes

Line planning techniques

Timetabling principles

Allocation of resources

Management of operations

Measures of realized operations

Improvements of existing services

Lecture notes

Lecture slides are provided.

Literature

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)


### Taught competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

#### Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### 101-0492-00L Microscopic Modelling and Simulation of Traffic Operations

#### Objective
- The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication. Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

#### Content
- In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:
  1. Car following models
  2. Lane change models
  3. Calibration and validation methodology

Specific tasks for the project will include:
- Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
- Calibrating and validating the simulation model.
- Redesigning/extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibration and validation) and implement, analyze and present a novel proposal, which will be compared with the base scenario. Upon completion of the course, the students will:
- Understand the basic models used in microscopic simulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.
- Evaluate alternative scenarios over the same network.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.
- Upon completion of the course, the students will:
  - Understand the basic models used in microscopic simulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
  - Design a road transport network inside the simulation software.
  - Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
  - Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
  - Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

#### Lecture notes
- The lecture notes and additional handouts will be provided before the lectures.

#### Literature
- Additional literature recommendations will be provided at the lectures.

#### Prerequisites / notice
- Students need to know some basic traffic operations. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

### 101-0527-10L Materials and Constructions

#### Abstract
- Building materials with a special focus on regenerative materials: earth, bio-based and reuse.
- Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction

#### Objective
- Special focus on regenerative materials: earth, bio-based and reuse
- The students will acquire knowledge in the following fields:
  - Fundamentals of material performance
  - Introduction to durability problems of building facades
  - Materials for the building envelope:
    - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
    - Insulating materials (bio-based vs conventional)
    - Air barrier, vapour barrier and sealants
    - Interior finishing
  - Assessment of materials and components behaviour and performance
  - Solutions for energy retrofitting of (historical) buildings
  - Aspects of sustainability and durability
After successfully completing this course the students will be able to:

- All documents for certification labels as well as detail plans of the buildings will be available for the students.
- The slides from the presentations will be made available.
- Three buildings case study will be presented.

**Objective**

After this course, the students are able to understand and use the different certification labels. They have a clear view of what the labels take into consideration and what they don't.

**Content**

- Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.
- This alternance of working session on one specific criteria for one specific building followed by a group presentation and discussion to compare labels is repeated for the different focus point (operation energy, mobility, daylight, indoor air quality).
- The slides from the presentations will be made available.

**Literature**

All documents for certification labels as well as detail plans of the buildings will be available for the students.

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**101-0587-00L Workshop on Sustainable Building Certification**

**W** 3 credits  2G

*Does not take place this semester.*

*Number of participants limited to 25*

**Abstract**

Building labels are used to certify buildings and neighbourhoods in term of sustainability. Many different labels have been developed and can be used in Switzerland (LEED, DGNB, SNBS, Minergie, 2000-Watt-Site). In this course the differences between the certification labels and its application on 3 emblematic case study buildings will be discussed.

**Objective**

After this overall general presentation and in order to have a closer look to specific aspects of sustainability, students will work in groups and assess during or one two weeks this specific criteria on one of the case studies presented before. This practical hands on the label will end with a presentation and a discussion where we will highlight differences between the labels.

**Content**

Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

- This alternance of working session on one specific criteria for one specific building followed by a group presentation and discussion to compare labels is repeated for the different focus point (operation energy, mobility, daylight, indoor air quality).
- The slides from the presentations will be made available.

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**101-0123-00L Structural Design**

**W** 3 credits  2G

F. Bertagna, D. Tanadini, P. Block, P. Ohlbrock, J. Schwartz

**Abstract**

The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects.

**Objective**

After successfully completing this course the students will be able to:

1. Critically question structural design concepts of historical and contemporary references
2. Use graphic statics and strut-and-tie models based on the Theory of Plasticity to describe the load bearing behavior of structures
3. Understand different construction technologies and have an awareness of their potential for structural design
4. Use contemporary digital tools for the design of structures in equilibrium
5. Design an appropriate structural system for a given design task taking into account architectural considerations

**Content**

The goal of the course is to introduce the civil engineering students to Structural Design, which is understood as a discipline that relates structural behavior, construction technologies and architectural concepts. Hence, the course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects in half of a semester: a mainly theoretical one (including the teaching of graphic statics and a mainly applied one (focused on the development of a design project by the students using digital form-finding tools).

**Theory**

Graphic statics is a graphical method developed by Prof. Karl Culmann and firstly published in 1864 at ETH Zurich. In this approach to structural analysis and design, geometric construction techniques are used to visualize the relation between the geometry of a structure and the forces acting in and on it, represented by geometrically dependent form and force diagrams.

The course will firstly review the main principles of graphic statics through a series of frontal lectures and discuss the relationship to analytical statics. Graphic statics is then used as an operative tool to design structures in equilibrium based on the lower bound theorem of the Theory of Plasticity. Additionally, the course will introduce contemporary methodologies and tools (parametric CAD software) for the interactive application of equilibrium modelling in the form of short workshops. The students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

**Design Project**

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students' ability to integrate architectural considerations into their structural design.

**Literature**

"Faustformel Tragwerksentwurf" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2015, ISBN 978-3-421-04012-1)


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**101-0267-01L Numerical Hydraulics**

**W** 3 credits  2G

M. Holzner

**Abstract**

In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.

**Objective**

The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.
Content
The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their
applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and
finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the
shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the
students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Lecture notes
Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

Literature
Given in lecture

★★ Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>Master's Thesis</td>
<td>O</td>
<td>20</td>
<td>43D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen specialisations and has to be
completed within 18 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and
to produce scientifically structured work.

**Objective**
To work independently and to produce a scientifically structured work.

**Content**
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the
professor.

► Master Studies (Programme Regulations 2006)

★★ Projects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
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<td>Project on Construction Engineering</td>
<td>W</td>
<td>9</td>
<td>19A</td>
<td>Supervisors</td>
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<tr>
<td>101-0298-01L</td>
<td>Project on Hydraulic Engineering and Water Resources Management</td>
<td>W</td>
<td>9</td>
<td>19A</td>
<td>Supervisors</td>
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<tr>
<td>101-0398-01L</td>
<td>Project on Geotechnical Engineering</td>
<td>W</td>
<td>9</td>
<td>19A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>101-0498-01L</td>
<td>Project on Transport Systems</td>
<td>W</td>
<td>9</td>
<td>19A</td>
<td>Supervisors</td>
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<tr>
<td>101-0598-01L</td>
<td>Project on Construction and Maintenance Management</td>
<td>W</td>
<td>9</td>
<td>19A</td>
<td>Supervisors</td>
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<tr>
<td>101-0698-01L</td>
<td>Project on Materials and Mechanics</td>
<td>W</td>
<td>9</td>
<td>18A</td>
<td>Supervisors</td>
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</tbody>
</table>

**Abstract**
Working on a concrete task in Construction Engineering
Working on a concrete task in Hydraulic Engineering
Working on a concrete task in Geotechnical Engineering
Working on a concrete task in Transport Systems
Working on a concrete task in Construction Engineering and Management
Working on a concrete task in Materials and Mechanics

**Objective**
Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated
task.

**Content**
The project work is supervised by a professor. Students can choose from different subjects and tasks.
How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design instruments to the students to use, test, and start their designs. Can urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational transformations in today's urbanization processes. Each lecture explores one city's spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations. In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations. Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today's economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

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Content

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect on it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

Lecture notes

The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

101-0599-10L New Materiality for the Passage Notre Dame W 2 credits 4P G. Habert

Abstract

The workshop aims at developing low carbon and long lasting materials for the renovation of the passage Notre Dame.

Objective

Students will work to develop materials from on-site resources: earth, crushed bricks and concrete, plaster and stone.

Students will learn about embodied emissions of material production and how to overcome durability issues related with low carbon materials.

It’s an hands-on workshop which lasts 10 days and is closed by a presentation in front of the main actors of the project: city of Paris, architects, industries.

Content

On the 27th June 2022, the team led by landscape designer Bas Smets with GRAU as urban planners and architects and Neufville-Gayet as heritage architects won the competition of the surroundings of Notre Dame Cathedral. They won with the idea to develop a material made with the raw elements from the site that can contribute to a long term discussion between the material history and future use of an underground space by the next generations. Based on the first mix design developed, this workshop aims to deepen the research on this material potential.

The workshop is articulated around central questions:

- How to design a material for eternity if it is made out rubbles of concrete, earth and stone?
- Should we design for eternity or accept decay?

And more fundamentally, how much carbon emission is it reasonable to emit for a project that will transform the main square in front of an eight hundred years old cathedral? This questions the reason of what heritage do we want to bequeath to the next generation? A Cathedral square and/or a climate and functioning ecosystem that allows them to thrive?

The workshop is based on a combination of hands-on experiments and guest lectures on the architectural intention around Notre Dame renovation, on Life Cycle Assessment and material science of building materials.

The first week explores the influence of processing and material mix design on colors and textures.

The second week dives into durability questions, maintenance and transformations over decades and centuries.

By the end of the workshop, the students will present by group their work to selected stakeholders involved in the project as well as key experts from architecture preservation, material and sustainability science.

Low Carbon materials explored during workshop is mainly poured earth, or earth concrete, which is a new technology well adapted to cities areas. The earth as liquid form is poured into a formwork and uncast after several hours to produce wall elements. Floors can be also done with this technology as it is currently done with concrete slab. It is a local material when excavated material from the site is used. It is nearly zero carbon as the additives used to modify its properties (water resistance, strength, fluidity) require low energy for their production (bio-additives...) and circular as the material can be returned to nature without environmental and societal impact. We will work with earth, limestone, plaster and demolished bricks and concrete as they are the main materials available in Paris.

Prerequisites / notice

A strong motivation to hands on experiments and a deep commitment to sustainability.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

see Science in Perspective: Language Courses ETH/UZH

Course Units for Additional Admission Requirements

The courses below are only available to MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0710-00L</td>
<td>Digital Engineering</td>
<td>E-</td>
<td>3</td>
<td>4G</td>
<td>to be announced</td>
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</table>

Remark: Will only be offered as of FS23.
### Civil Engineering Master - Key for Type

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

### Key for Hours

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

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### Biochemistry – Chemical Biology Bachelor

#### Core Courses First Year Examination

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0011-02L</td>
<td>General Chemistry (Inorganic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
<tr>
<td></td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
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</tr>
<tr>
<td></td>
<td>Objective</td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 529-0011-03L | General Chemistry (Organic Chemistry) I | O    | 3    | 2V+1U | P. Chen  |
|              | Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions. |
|              | Objective | Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry. |
|              | Content   | Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicity, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intermolecular interactions. |
|              | Lecture notes | Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt |

| 529-0011-01L | General Chemistry (Physical Chemistry) I | O    | 3    | 2V+1U | H. J. Wörner |
|              | The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding. |
|              | Objective | After the lecture, students will be able to, |
|              |          | - to calculate physical quantities and their units which are important for chemistry, |
|              |          | - name some properties of chemically relevant particles and propose experimental methods to determine these properties, |
|              |          | - atomic orbital properties of electromagnetic radiation and matter and propose experimental methods for their detection, |
|              |          | - independently solve the Schrödinger equation for a molecular multi-particle system, |
|              |          | - to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them, |
|              |          | - analyze and calculate absorption and emission spectra of single-electron atoms, |
|              |          | - to set up the Schrödinger equation for a molecular multi-particle system, |
|              |          | - solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems, |
|              |          | - molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model, |
|              |          | - to calculate the density of states and picture the qualitative form of the orbitals and molecular orbitals of the hydrogen atom, |
|              |          | - the structure of the periodic table of elements with the help of the orbital concept, |
|              |          | - recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and |
|              |          | - explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom, |
|              |          | - establish term symbols for atomic ground states. |
|              | Content | Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionization energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: valence bonding, covalent bonding, molecular orbitals. |
|              | Lecture notes | See homepage of the lecture. |
|              | Literature | See homepage of the lecture. |
|              | Prerequisites / notice | Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung. |
|              | Taught competencies | Subject-specific Competencies |
|              |              | Concepts and Theories |
|              |              | assessed |
|              |              | Techniques and Technologies |
|              |              | assessed |
|              |              | Analytical Competencies |
|              |              | assessed |
|              |              | Decision-making |
|              |              | not assessed |
|              |              | Media and Digital Technologies |
|              |              | not assessed |
|              |              | Problem-solving |
|              |              | assessed |
|              |              | Project Management |
|              |              | not assessed |
|              |              | Communication |
|              |              | not assessed |
|              |              | Cooperation and Teamwork |
|              |              | not assessed |
|              |              | Customer Orientation |
|              |              | not assessed |
|              |              | Leadership and Responsibility |
|              |              | not assessed |
|              |              | Self-presentation and Social Influence |
|              |              | not assessed |
|              |              | Sensitivity to Diversity |
|              |              | not assessed |
|              |              | Negotiation |
|              |              | not assessed |
|              |              | Adaptability and Flexibility |
|              |              | not assessed |
|              |              | Creative Thinking |
|              |              | not assessed |
|              |              | Critical Thinking |
|              |              | assessed |
|              |              | Integrity and Work Ethics |
|              |              | assessed |
|              |              | Self-awareness and Self-reflection |
|              |              | not assessed |
|              |              | Self-direction and Self-management |
|              |              | assessed |
The lecture is supported by scripts.

The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

The newly conceived lecture is supported by scripts.


### 401-0271-00L Mathematical Foundations I: Analysis A

**Objective**
Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

**Content**
Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

**Literature**
G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag
R. Sperb/M. Akveld: Analysis I (vdf)
L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

### Taught competencies

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

### Taught competencies

<table>
<thead>
<tr>
<th>529-0001-00L Introduction to Computer Science</th>
</tr>
</thead>
</table>

**Objective**
Acquire a starting package concerning the computational aspects of natural sciences; discuss fundamentals of computer architecture, languages, algorithms and programming with an eye to their application in the area of chemistry, biology and material science.

**Content**
Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation; Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

**Literature**
Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.

See: www.csms.ethz.ch/education/infol

For more information about the lecture: www.csms.ethz.ch/education/infol

**Data:** 18.08.2022 12:39  **Autumn Semester 2022**  **Page 226 of 2345**
## Examination Blocks

### Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>529-0121-00L</td>
<td>Inorganic Chemistry I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>H. Grützmacher, P. Steinegger</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals as well as the lanthanides and actinides. Introduces methods of characterization, physical-chemical properties of coordination compounds as well as principles of radiochemistry.</td>
<td></td>
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<tr>
<td><strong>Objective</strong></td>
<td>The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. The students will acquire knowledge on the fundamentals of radioactive decay and radiochemistry. Furthermore, they will be familiar with the basics of inorganic chemistry of lanthanides and actinides.</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>This course consists of the following parts, which introduce the students to the chemistry of transition metals as well as lanthanides and actinides: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) Properties and characterization of coordination compounds; 9) Introduction to radiochemistry; 10) Principles of the chemistry of the lanthanides and actinides.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Eine kommentierte Foliensammlung ist im HCI-Shop erhältlich.</td>
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<tr>
<td><strong>Taught competencies</strong></td>
<td>Subject-specific Competencies: Concepts and Theories assessed Techniques and Technologies assessed</td>
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<td></td>
<td>Method-specific Competencies: Analytical Competencies not assessed Decision-making not assessed Media and Digital Technologies not assessed Problem-solving assessed</td>
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<tr>
<td></td>
<td>Social Competencies: Communication not assessed Cooperation and Teamwork not assessed Customer Orientation not assessed Leadership and Responsibility not assessed Self-presentation and Social Influence not assessed Sensitivity to Diversity not assessed Negotiation not assessed</td>
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<tr>
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<td>Personal Competencies: Adaptability and Flexibility not assessed Creative Thinking assessed Critical Thinking assessed Integrity and Work Ethics not assessed Self-awareness and Self-reflection not assessed Self-direction and Self-management not assessed</td>
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<tr>
<td>529-0221-00L</td>
<td>Organic Chemistry I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>H. Wennemers</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.</td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>The lecture slides, problem sets, and additional documents are provided online. Link: <a href="https://wennemers.ethz.ch/education.html">https://wennemers.ethz.ch/education.html</a></td>
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<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4</td>
<td>3V+1U</td>
<td>R. Signorell</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Introduction to Chemical Reaction Kinetics</td>
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<tr>
<td><strong>Lecture notes</strong></td>
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<td><strong>Prerequisites</strong></td>
<td>Voraussetzungen:</td>
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<tr>
<td><strong>notice</strong></td>
<td>- Mathematik I und II</td>
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<tr>
<td></td>
<td>- Allgemeine Chemie I und II</td>
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<tr>
<td></td>
<td>- Physikalische Chemie I</td>
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</tbody>
</table>

402-0043-00L | Physics I                   | O    | 4    | 3V+1U  | S. P. Quanz       |
| **Abstract** | Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves. |      |      |        |                  |
Nach diesem Kurs können Sie mit der Statistiksoftware R Daten einlesen, auf vielfältige Art verarbeiten und Grafiken für Berichte oder Vertiefung von Statistikmethoden. Nach dem detailierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

**Statistics II**

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0643-13L</td>
<td>Statistics II</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>J. Dambon</td>
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</table>

**Analytical Chemistry I**

<table>
<thead>
<tr>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0051-00L</td>
<td>Analytical Chemistry I</td>
<td>O</td>
<td>3</td>
<td>3G</td>
<td>D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi</td>
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**Pharmacology and Toxicology I**

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>535-0521-00L</td>
<td>Pharmacology and Toxicology I</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>U. Quitterer, J. Abd Alla</td>
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**Organic Chemistry for Biochemistry and Chemical Biology**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0018-00L</td>
<td>Organic Chemistry for Biochemistry and Chemical Biology</td>
<td>O</td>
<td>6</td>
<td>3G</td>
<td>J. W. Bode</td>
</tr>
</tbody>
</table>

**Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids)**

**Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).**

**Lecture notes**

The lecture follows the book “Physics” by Paul A. Tipler, Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company.

**Objective**

The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

**Content**

Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids).

**Lecture notes**

The lecture follows the book “Physics” by Paul A. Tipler, Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company.

**Objective**

Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

**Content**

Nach diesem Kurs können Sie mit der Statistiksoftware R Daten einlesen, auf vielfältige Art verarbeiten und Grafiken für Berichte oder Vertiefung von Statistikmethoden. Nach dem detailierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

**Script**

A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

**Lecture notes**

Script will be for the production price

**Literature**

- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

**Exercises**

Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 “Instrumental analysis of organic compounds” (4th semester) is recommended.

**Prerequisites / notice**

Excercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 “Instrumental analysis of organic compounds” (4th semester) is recommended.

**Physiology (neurophysiology, sensory reception, neuromotor control, autonomic nervous system)**

**Objective**

This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

**Content**

The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

**Lecture notes**

A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

**Literature**

- Goodman and Gilman`s The Pharmacological Basis of Therapeutics
- Laurence Brunton, Bjorn Knollman, Randa Hilal-Dandan.
- Goodman and Gilman’s The Pharmacological Basis of Therapeutics 14th Edition (expected Dec. 2022)

**Prerequisites / notice**

or 14th Edition (expected Dec. 2022)

**Voraussetzungen: Abschluss Grundstudium**
Lecture notes and other material relevant for the course will be available online under https://bode.ethz.ch/education.html.

Relevant research articles and review papers will be available in the course and course material.

This is an advanced organic chemistry course. Prior knowledge of organic synthesis, reactions, and mechanisms is required. Familiarity with biochemistry and biology is recommended.

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

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies

Social Competencies
- Communication

Personal Competencies
- Adaptability and Flexibility

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
- Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
- Basics:
  - Creighton, T.E., Proteins, Freeman, (1993)
  - Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

Molecular and Structural Biology I: Protein Structure and Function

D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
- Basics:
  - Creighton, T.E., Proteins, Freeman, (1993)
  - Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0124-00L</td>
<td>BCB I: General Chemistry</td>
<td>O</td>
<td>6</td>
<td>8P</td>
<td>H. V. Schönberg</td>
</tr>
</tbody>
</table>

Abstract
Qualitative analysis (cation and anion detection), acid-base equilibrium (pH, titrations, buffers), precipitation equilibrium (gravimetry, potentiometry, conductivity), redox reactions (synthesis, redox titrations, galvanic elements), metal complexes (synthesis, complexometric titration)
### Objective
Qualitative analysis (simple cation and anion separation, detection of cations and anions), acid-base equilibrium (acid and base strength, pH and pK_a values, titrations, buffers, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation numbers and redox behavior (synthesis, redox titrations, galvanic elements), metal complexes (synthesis of complexes, ligand exchange reactions, complexometric titration).

### Content
The practical course in general chemistry is intended to introduce students to scientific work and familiarize them with simple experimental work in the laboratory. The aim is to gain initial experience with the reaction behavior of substances. In addition to a series of qualitative experiments, qualitative experiments provide knowledge about the chemical properties of substances. The individual experiments are selected in such a way that the most varied possible overview of substance classes and phenomena of chemistry is obtained.

### Literature
- [https://moodle-app2.let.ethz.ch](https://moodle-app2.let.ethz.ch)

### Prerequisites / notice
Safety concept: [https://chab.ethz.ch/studium/bachelor1.html](https://chab.ethz.ch/studium/bachelor1.html)

### 529-0016-00L BCB III: Organic Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0016-00L</td>
<td>Laboratory Course in Organic Chemistry for students of &quot;Biochemistry - Chemical Biology&quot;</td>
<td>O</td>
<td>8</td>
<td>12P</td>
<td>J. W. Bode</td>
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</tbody>
</table>

#### Abstract
Introduction to basic techniques used in the organic laboratory. Understanding organic reactions through experiments.

#### Literature
- [see https://bode.ethz.ch/education/bcb-iii/bcb-iii-lab-course.html](https://bode.ethz.ch/education/bcb-iii/bcb-iii-lab-course.html)

#### Prerequisites / notice
- Basisspruch + BCB I: General Chemistry

#### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Taught competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
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</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Taught competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<table>
<thead>
<tr>
<th>Social Competencies</th>
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<td>Communication</td>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Negotiation</td>
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<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Taught competencies</th>
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</thead>
<tbody>
<tr>
<td>Adaptability and Flexibility</td>
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</tr>
<tr>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</table>

### Block Courses

Please note the ETH admission criteria for the admission of ETH students to ETH block courses on the block course registration website under "allocation".

### Block Courses in the 1st half of the Semester
20.9.2022 - 04.11.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

#### Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

#### Objective
Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

#### Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

#### Literature
No course textbooks. Literature will be indicated or provided by the supervising TAs.

#### Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.
Block Courses in the 2nd half of the Semester

08.11.2022 - 23.12.2022

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

- Admittance is limited and depends on the availability of hosting research labs.
- Interested students are asked to contact Prof. C. Thilgen (thilgen@org.chem.ethz.ch) before the end of the preceding semester for further details.
- In case of admittance, the actual enrolment needs to be done via the D-BIOL study administration.

Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective
Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Lecture notes
No course notes.

Literature
No set textbooks. Literature will be indicated or provided by the supervising TAs.

Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.

Taught competencies

<table>
<thead>
<tr>
<th>Competency</th>
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<tr>
<td>Subject-specific Competencies</td>
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<tr>
<td>Concepts and Theories</td>
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<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Cooperation and Teamwork</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Creative Thinking</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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Block courses in the 1st quarter of the semester

20.9.2022 - 12.10.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>551-1129-00L</td>
<td>Understanding and Engineering Microbial Metabolism</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>J. Vorholt-Zambelli</td>
</tr>
</tbody>
</table>

Number of participants limited to 6.

The enrolment is done by the D-BIOL study administration.

Abstract
This laboratory course has a focus on current research topics in our laboratory related to metabolic engineering, the general understanding of metabolism, and is partially focused on one carbon metabolism. Projects will be conducted in small groups.

Objective
The course aims at introducing technologies to investigate bacterial metabolism and key principles of metabolic engineering. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular genetic, biochemical and analytical techniques including metabolomics. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.

Content
The course and will include topics such as pathway elucidation & engineering and related ongoing research projects in the lab.

Experimental work applied during the course will comprise methods such as cloning work & transformation, growth determination, enzyme activity assays, liquid-chromatography mass-spectrometry and dynamic labeling experiments.

Lecture notes
None
## 551-141-00L The Mechanisms of Natural Transformation in Competent Gram-Negative Bacteria

**Objective**

Students will carry out defined research projects related to the current research topics of the Hospenthal Group. The topics will include protein expression of pili and/or other competence proteins from Gram-negative bacteria, protein purification using affinity chromatography, crystallisation experiments and analysis of assembled pili by electron microscopy.

**Content**

The course should enable students to understand concepts of protein expression, purification and the characterisation of biomolecular interactions. In addition, students will learn some basic principles of X-ray crystallography and electron microscopy.

**Prerequisites / Literature**

- Any required reading of literature will be discussed at the beginning of the course.
- Research projects on the model pathogen Salmonella.
- Lecture notes: Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.
- Personalized Medicine

## 551-1415-00L Image-Based Drug Screening in Human Blood for Personalized Medicine

**Objective**

Take the students through the entire workflow from experimental design, to screen, to imaging and analysis.

- Learn to design an image-based screening experiment
- Observe human blood sample handling
- Perform immunofluorescence & automated confocal microscopy
- Image analysis and result interpretation
- Result presentation

**Literature**

- Relevant study: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30208-9/fulltext
- Editorial commentary: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30213-2/fulltext

## Block courses in the 2nd quarter of the semester

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
551-0345-00L | Mechanisms of Bacterial Pathogenesis | W | 6 credits | 7P | W.-D. Hartl, B. Nguyen

**Objective**

Introduction to a current topic in cellular microbiology and/or molecular genetics of a bacterial pathogen. Experimental work in the research lab and introduction to the current lab techniques. This includes contributions to the analysis of animal experiment. You will work with the current research literature in bacterial pathogenesis and write a research protocol.

**Content**

Research projects on the model pathogen Salmonella.

**Lecture notes**

none.

**Literature**

Literature will be selected with reference to the assigned research project.

551-0421-00L | Biology and Ecology of Fungi in Forests | W | 6 credits | 7P | S. Prospero, I. L. Brunner, M. Peter Baltensweiler

**Objective**

Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

**Content**

- Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.
Participation in a project from the following list is possible:

1) Photosynthesis: How is photosynthesis regulated and how is photoassimilated carbon distributed in plants? 2) Biology of chloroplasts: How do chloroplasts develop and how is their function coordinated with that of the endoplasmic reticulum and nuclear processes? 3) Starch biosynthesis and degradation: How are complex, semi-crystalline starch granules produced from monosaccharides and how is the amylopectin network built in the whole cell? 4) Plant metabolism: How are carbon assimilation and storage regulated during the day? 5) Inoculation: How do plant microorganisms interact with the host plant and how are they planned in the longer term.

The enrolment is done by the D-BIOL study administration.

Objective

The course will introduce the students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course.

Content

Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field.

Lecture notes

No script

Literature

The recommended literature, including reviews and primary research articles, will be provided during the course. Students will have the opportunity to present their projects and discuss recent publications.

Prerequisites / notice

- It is recommended to bring your own computer with a Python installation to the course
- simple computers can be provided
- Programming basics with Python

The course will consist of a series of lectures, assignments for implementing elementary tasks in Python, project development and discussion workshops, and a half week of practical work implementing a Python script as a solution to a real world problem associated with sequence analysis. At the end of the course, students will explain their solutions and demonstrate the functionality of their implementations, which will then be discussed and commented on by the group. It is expected that students will be able to apply the knowledge to improve on concrete problems.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 15.

The enrolment is done by the D-BIOL study administration.

Abstract

Methods for analyzing animal genomes are increasingly becoming important for applications in human health and biotechnology suggesting that the experience will be useful to develop relevant expertise for a broad range of functions. Students will have the opportunity to advance their knowledge in programming by focusing on algorithms for genome and gene sequence analysis. A major goal of the course will be to lead the student to an independent and empowered attitude towards computational problems. For reaching this goal the students will work on an implementation of a solution for a set real-world problem in genome and sequence analysis under guided supervision.

Content

- Understanding the information in biological sequences and quantifying similarity
- Introduction to algorithms for sequence comparison and searches
- Implementation of sequence comparisons and searches in Python
- Accessing data formats associated with genome sequence analysis tasks
- Understanding the anatomy of a real world sequence analysis project
- Applying tools for sequence alignment and estimating error rates
- Ability to implement a solution to a problem in sequence analysis using Python
- Accessing genome annotation and retrieving relevant information in Pandas
- Application of Genomic intervals and arrays for sequence analysis with HTSeq

No script

Literature

The recommended literature, including reviews and primary research articles, will be provided during the course. Students will have the opportunity to present their projects and discuss recent publications.

Prerequisites / notice

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No script

Literature

The recommended literature, including reviews and primary research articles, will be provided during the course. Students will have the opportunity to present their projects and discuss recent publications.

Prerequisites / notice

- It is recommended to bring your own computer with a Python installation to the course
- simple computers can be provided
- Programming basics with Python

The course will consist of a series of lectures, assignments for implementing elementary tasks in Python, project development and discussion workshops, and a half week of practical work implementing a Python script as a solution to a real world problem associated with sequence analysis. At the end of the course, students will explain their solutions and demonstrate the functionality of their implementations, which will then be discussed and commented on by the group. It is expected that students will be able to apply the knowledge to improve on concrete problems.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 15.

The enrolment is done by the D-BIOL study administration.

Abstract

Methods for analyzing animal genomes are increasingly becoming important for applications in human health and biotechnology suggesting that the experience will be useful to develop relevant expertise for a broad range of functions. Students will have the opportunity to advance their knowledge in programming by focusing on algorithms for genome and gene sequence analysis. A major goal of the course will be to lead the student to an independent and empowered attitude towards computational problems. For reaching this goal the students will work on an implementation of a solution for a set real-world problem in genome and sequence analysis under guided supervision.

Content

- Understanding the information in biological sequences and quantifying similarity
- Introduction to algorithms for sequence comparison and searches
- Implementation of sequence comparisons and searches in Python
- Accessing data formats associated with genome sequence analysis tasks
- Understanding the anatomy of a real world sequence analysis project
- Applying tools for sequence alignment and estimating error rates
- Ability to implement a solution to a problem in sequence analysis using Python
- Accessing genome annotation and retrieving relevant information in Pandas
- Application of Genomic intervals and arrays for sequence analysis with HTSeq

No script

Literature

The recommended literature, including reviews and primary research articles, will be provided during the course. Students will have the opportunity to present their projects and discuss recent publications.

Prerequisites / notice

- It is recommended to bring your own computer with a Python installation to the course
- simple computers can be provided
- Programming basics with Python
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0739-01L</td>
<td>Biological Chemistry B: New Enzymes from Directed Evolution Experiments</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>P. A. Kast, K. Würth-Roderer</td>
</tr>
</tbody>
</table>

The enrolment is done by the D-BIOL study administration.

**Abstract**
During the block course in the fall semester, we will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The class with its very dense program consists of the practical course itself and an integrated series of seminar/lecture sessions.

**Objective**
All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

**Content**
The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel, teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

**Lecture notes**
A script will be distributed to the participants on the first day of the course.

**Literature**
General literature to "Directed Evolution" and chorismate mutases, e.g.:


Further information will be indicated in the distributed script.

**Prerequisites / notice**
This laboratory course will involve experiments that require a tight schedule and, particularly in the second half, very long (!) working days. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast.

For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

**Safety concept**: https://chab.ethz.ch/studium/bachelor1.html.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Integrity and Work Ethics</td>
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</table>

- Techniques: https://chab.ethz.ch/studium/bachelor1.html

**Literature**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-4020-00L</td>
<td>Experimental Food Microbiology for Biologists</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>M. Schuppier, M. Loessner, Y. Shen</td>
</tr>
</tbody>
</table>

Number of participants limited to 12

**Prerequisites**: It is recommended to attend the course Lebensmittel-Mikrobiologie (752-4005-00L) as a preparation. The course can only be booked via the Biology Student secretariat

**Abstract**
Teaching of basic experimental knowledge for detection and identification of microorganisms in food. Practical experiments were accompanied by theoretical introductions. Students become acquainted with classical and state-of-the-art molecular techniques for the rapid detection of food-borne pathogens and experiments in dependence on current research topics of the Laboratory of Food Microbiology.

**Objective**
Introduction of methods and techniques of food microbiology

**Content**
Teaching of basic experimental knowledge for detection and identification of foodborne pathogens by applying state-of-the-art techniques as well as modern molecular techniques for the rapid identification of relevant foodborne pathogens.

**Prerequisites / notice**
Handouts were provided at the start of the course

- Handouts: https://chab.ethz.ch/studium/bachelor1.html

- Literature:
  - Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
  - Süssmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

**Data**: 18.08.2022 12:39

**Autumn Semester 2022**
During the block course, each student will learn how to handle aggregation-prone peptides, characterize their aggregation state and structure as well as assess their ability to template their own chemical synthesis.

Objective
During the block course, each student will learn how to handle aggregation-prone peptides, characterize their aggregation state and structure as well as assess their ability to template their own chemical synthesis.

Content
The course is divided between lectures practical work in the lab. The lectures will introduce the general topic of amyloids and in particular their potential role in the origin of molecular complexity, as well as cover the theory and the practice behind the tools that are used to characterize peptide amyloids. The practical work in the lab will allow the students to gain hands-on experience working on a novel peptide that has yet to be characterized. Since the course consists of genuine research we also hope that new discoveries will be made that will provide insights into the role that amyloids may have played in the origin of life.

Lecturers
R. Riek, J. Greenwald

Report
A script will be distributed to the participants on the first day of the course.

Literature

Further literature will be indicated in the distributed script.

551-0361-00L Biology of Bryophytes and Ferns

Number of participants limited to 16.

Abstract
Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes; field trip.

Objective
Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes.

Content
Ferns: basic knowledge on the life cycle, morphology, evolution and ecology of ferns; identification of Swiss fern species; field trips.

Lecturers
R. Holderegger, A. L. Bergamini

Prerequisites / notice
Students have to present a poster on a special topic.

Literature

Grade according to poster presentation and contributions during the course.

551-1309-00L RNA-Biology

Number of participants limited to 17.

Abstract
Introduction to the diversity of current RNA-research at all levels from structural biology to systems biology using mainly model systems like S. cerevisiae (yeast), mammalian cells.

Objective
The students will obtain an overview about the diversity of current RNA-research. They will learn to design experiments and use techniques necessary to analyze different aspects of RNA biology. Through lectures and literature seminars, they will learn about the burning questions of RNA research and discuss approaches to address these questions experimentally. In practical lab projects the students will work in one of the participating laboratories. Finally, they will learn how to present and discuss their data in an appropriate manner. Student assessment is a graded semester performance based on individual performance in the laboratory, the written exam and the poster presentation.

Literature
Documentation and recommended literature will be provided at the beginning and during the course.

551-1417-00L In Vivo Cryo-EM Analysis of Dynein Motor Proteins

Number of participants limited to 5.

Abstract
Motor proteins convert chemical energy into mechanical motion. In this block course, we study dynein motor proteins in cilia. Dynein causes conformational change upon ATP hydrolysis and finally generate ciliary bending motion. Participants will analyze cryo-EM data of cilia and visualize in vivo 3D structure of dynesin to learn how motor protein function in the cell.

Objective
The goal of this course is to familiarize with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies on motor proteins. The main focus is 3D image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.

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Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. Their function is essential for intracellular transport, muscle contraction and other cellular motility as well as cell division. Motor proteins have been major targets of biophysical studies. There exist questions from atomic to tissue levels – how ATP hydrolysis causes conformational change of motor proteins; how their motion is regulated by calcium, phosphorylation and other factors; how motions of multiple motor proteins are coordinated to generate cellular motility. Structural biology has been playing central roles to answer these questions. X-ray crystallography and single particle cryo-EM address structural analysis at atomic resolution and try to reveal molecular mechanism of conformational change. Cryo-electron tomography analyze localization and 3D structure of motor proteins in the cell to explain how motions of molecular motors happen in the context of cellular environment and are integrated into cellular motion.

In this course, we study dyneins in cilia. Cilia are force-generating organelles, made by nine microtubules and thousands of dyneins. Dynein hydrolyzes ATP and undergoes conformational change, generating linear motion with respect to the microtubule. As a whole system, cilia integrate motions of these dyneins and orchestrate beating motion. To explain ciliary motion at molecular level, we need to know dynein conformational change in the cellular context. Cryo-electron tomography is recently developed technique to study molecular structures in vivo and therefore a suitable method to study dynein in cilia. Recently spatial resolution of these cryo-EM techniques was dramatically improved, driven by development of new types of detectors and electron optics. The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dynein, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH.

**Ejectives**

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0313-00L</td>
<td>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano</td>
</tr>
<tr>
<td>529-0041-00L</td>
<td>Medicinal Chemistry I</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>J. Hall</td>
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</table>

Languages:
- English
- German
- French

Prerequisites:
- 529-0051-00 "Analytische Chemie I (3. Semester)"
- 529-0058-00 "Analytische Chemie II (4. Semester)" (or equivalent)
Autumn Semester 2022

Taught competencies

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

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

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

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

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**Inorganic Chemistry III: Organometallic Chemistry and W**

- **529-0132-00L**
- **Title:** Inorganic Chemistry III: Organometallic Chemistry and W
- **W 4 credits 3G**
- **Authors:** M. Bezdek, C. Copéret

**Abstract**
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbonylation, C-C bond-forming and related reactions.

**Objective**
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

**Content**
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbonylation, C-C bond-forming and related reactions.

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**Cellular Biochemistry (Part I)**

- **551-0319-00L**
- **Title:** Cellular Biochemistry (Part I)
- **W 3 credits 2V**
- **Authors:** U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.
Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Lecture notes**
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.bioc.ethz.ch)

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

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**Science in Perspective**

- **Science in Perspective**
  - see Science in Perspective: Type A: Enhancement of Reflection Capability
  - **Recommended Science in Perspective (Type B) for D-CHAB**

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**Language Courses**

- **see Science in Perspective: Language Courses ETH/UZH**

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**Biochemistry – Chemical Biology Bachelor - Key for Type**

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<th>Type</th>
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<th>Compulsory</th>
<th>Eligible for Credits and Recommended</th>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>4 credits</td>
<td>Dr</td>
<td>O</td>
<td>W+</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>3G</td>
<td>O</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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Autumn Semester 2022

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<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Biology (General Courses)

Complementary Courses

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<thead>
<tr>
<th>Number</th>
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<td>376-1791-00L</td>
<td>Introductory Course in Neuroscience I (University of Zurich)</td>
<td>Z Dr</td>
<td>2 credits</td>
<td>2V</td>
<td>University lecturers</td>
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<td><em>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</em></td>
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<td><em>Mind the enrolment deadlines at UZH:</em></td>
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<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.</td>
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<td></td>
<td>The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>1) Human Neuroanatomy I&amp;II</td>
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<td>2) Comparative Neuroanatomy</td>
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<td>3) Building a central nervous system I,II</td>
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<td>4) Synapses I,II</td>
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<td>5) Glia and more</td>
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<td>6) Excitability</td>
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<td>7) Circuits underlying Emotion</td>
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<td>8) Visual System</td>
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<td>9) Auditory &amp; Vestibular System</td>
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<td>10) Somatosensory and Motor Systems</td>
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<td></td>
<td>11) Learning in artificial and biological neural networks</td>
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<tr>
<td></td>
<td>For doctoral students of the Neuroscience Center Zurich (ZNZ).</td>
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<tr>
<td>151-0927-00L</td>
<td>Rate-Controlled Separations in Fine Chemistry</td>
<td>Z Dr</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>M. Mazzotti, V. Becattini</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.</td>
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<td><strong>Objective</strong></td>
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<td><strong>Content</strong></td>
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<td>The class covers separation techniques that are central in the purification and downstream processing of chemicals and bio-pharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Recommendations for text books will be covered in the class</td>
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<td>Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)</td>
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<td><strong>Taught competencies</strong></td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td><strong>Social Competencies</strong></td>
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<td><strong>Personal Competencies</strong></td>
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<td>Creative Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>Z Dr</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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<td><strong>Abstract</strong></td>
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<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning &quot;good practice&quot; that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.</td>
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<td><strong>Content</strong></td>
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<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multcollinearity problems and model interpretation, as well as general modeling strategies.</td>
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<td>The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.</td>
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<td><strong>Lecture notes</strong></td>
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<td>A script will be available.</td>
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Literature
- Faraway (2005): Linear Models with R
- Faraway (2006): Extending the Linear Model with R
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

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

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

551-1619-00L Structural Biology
Z Dr 1 credit 1K
R. Glockshuber, F. Allain, N. Ban, K. Locher, M. Pilhofer, E. Weber-Ban, K. Wüthrich

Abstract
The course consists of a series of research seminars on Structural Biology, Biochemistry and Biophysics, given by both scientists of the National Center of Competence in Research (NCCR) in Structural Biology and external speakers. Information on the individual seminars is provided on the following websites:
http://www.structuralbiology.uzh.ch/educ002.asp
http://www.biol.ethz.ch/dbiol-cal/index

Objective
The goal of this course is to provide doctoral and postdoctoral students with a broad overview on the most recent developments in biochemistry, structural biology and biophysics.

851-0180-00L Research Ethics
Z Dr 2 credits 2G
G. Achermann, P. Emch

Number of participants limited to 40

Abstract
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective
Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people's arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning

1. Ethics - the basics
1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QR/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!), connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...).

Subject-specific Competencies

Concepts and Theories assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making assessed

Problem-solving assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-awareness and Self-reflection assessed

Cancer: Fundamentals, Origin and Therapy

Z 2 credits 2G H. Nägeli

Abstract

Objective
Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or chemical exposure and resulting in a tumor. They are able to list important cancer-inducing agents and explain the respective mechanism of action. They have knowledge of significant risk factors for cancer diseases. They are confronted with the basics of toxicology and they can explain the principle of the most common therapeutic strategies.

Content
The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process. Classes of chemical compounds that induce cancer are discussed as well as the reactive metabolites that may be built from. Covalent binding to DNA is discussed and different types of mutations resulting thereof. A selection of proto-oncogenes and tumor suppressor genes is presented. Their function will be discussed as well as the changes which are found in these genes in tumor cells, starting from single nucleotide exchanges up to large deletions.

The reason for genetic predisposition to cancer will be discussed as well as cancer relevant aspects of cell cycle regulation. The role of tumor microenvironments and phenomena like angiogenesis and metastasis are presented as well as the mechanisms that protect the genome from mutagenic damage. Further subjects address old and new strategies of cancer treatment. Personalised cancer treatment.

Lecture notes
Handouts with reproductions of all presented transparencies will be distributed.

Literature

additional information is given during the lecture
### Prerequisites / notice

**Taught competencies**

- The lecture requires an active participation of the students. All students will participate in individual or group work focusing on specific subject of the lecture. Students will have ample time for preparation during lecture time.

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**

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

**Personal Competencies**

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

### 401-5640-00L ZüKoSt: Seminar on Applied Statistics

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<th>Z Dr</th>
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**Abstract**

About 5 talks on applied statistics.

**Objective**

See how statistical methods are applied in practice.

**Content**

There will be about 5 talks on how statistical methods are applied in practice.

**Prerequisites / notice**

This is no lecture. There is no exam and no credit points will be awarded. The current program can be found on the web: [http://stat.math.ethz.ch/events/zukost](http://stat.math.ethz.ch/events/zukost).

Course language is English or German and may depend on the speaker.

### 551-1109-00L Seminars in Microbiology

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<tr>
<th>Z Dr</th>
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<tbody>
<tr>
<td>S. Sunagawa, W.-D. Hardt, M. Künzler, J. Piel, J. Vorholt-Zambelli</td>
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**Abstract**

Seminars by invited speakers covering selected microbiology themes.

**Objective**

Discussion of selected microbiology themes presented by invited speakers.

### 401-0620-00L Statistical Consulting

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<th>Z Dr</th>
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<tr>
<td>M. Kalisch, L. Meier</td>
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**Abstract**

The Statistical Consulting service is open for all members of ETH, including students, and partly also to other persons.

**Objective**

Advice for analyzing data by statistical methods.

**Content**

Students and researchers can get advice for analyzing scientific data, often for a thesis. We highly recommend to contact the consulting service when planning a project, not only towards the end of analyzing the resulting data!

**Prerequisites / notice**

This is not a course, but a consulting service. There are no exams nor credits.

Contact: beratung@stat.math.ethz.ch . Tel. 044 632 2223. See also [http://stat.ethz.ch/consulting](http://stat.ethz.ch/consulting)

Requirements: Knowledge of the basic concepts of statistics is desirable.

### 551-0512-00L Current Topics in Molecular and Cellular Neurobiology

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<tr>
<td>U. Suter</td>
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**Abstract**

The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

**Objective**

The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

**Content**

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

**Lecture notes**

Presentations will be made available after the seminars.

**Prerequisites / notice**

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

### 551-0737-00L Ecology and Evolution: Interaction Seminar

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<td>S. Bonhoeffer</td>
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**Abstract**

Interaction seminar. Student-mediated presentations, guests and discussions on current themes in ecology, evolutionary and population biology.

**Objective**

Getting familiar with scientific arguments and discussions. Overview of current research topics. Making contacts with fellow students in other groups.

**Content**

Scientific talks and discussions on changing subjects.

**Lecture notes**

None
<table>
<thead>
<tr>
<th>551-0509-00L</th>
<th>Current Immunological Research in Zurich</th>
<th>Z Dr</th>
<th>0 credits</th>
<th>1K</th>
<th>R. Spörri, C. Halin Winter, W.-D. Hardt, M. Kopf, S. R. Leibundgut, A. Oxenius, University lecturers</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This monthly meeting is a platform for Zurich-based immunology research groups to present and discuss their ongoing research projects. At each meeting three PhD students or Postdocs from the participating research groups present an ongoing research project in a 30 min seminar followed by a plenary discussion.</td>
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<td><strong>Objective</strong></td>
<td>The aim of this monthly meeting is to provide further education for master and doctoral students as well as Postdocs in diverse topics of immunology and to give an insight in the related research. Furthermore, this platform fosters the establishment of science- and technology-based interactions between the participating research groups.</td>
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<td><strong>Content</strong></td>
<td>Presentation and discussion of current research projects carried out by various immunology-oriented research groups in Zurich.</td>
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<td><strong>Lecture notes</strong></td>
<td>none</td>
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<tr>
<th>551-1106-00L</th>
<th>Progress Reports in Microbiology and Immunology</th>
<th>Z Dr</th>
<th>0 credits</th>
<th>5S</th>
<th>J. Piel, W.-D. Hardt, A. Oxenius, J. Vorholt-Zambelli</th>
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<tr>
<td><strong>Abstract</strong></td>
<td>Students must sign up via secr.micro.biol.ethz.ch</td>
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<td><strong>Objective</strong></td>
<td>Presentation and discussion of current research results in the field of Microbiology and Infection Immunology</td>
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<td><strong>Content</strong></td>
<td>Precise and transparent presentation of research findings in relation to the current literature, critical discussion of experimental data and their interpretation, development and presentation of future research aims</td>
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<th>551-0209-00L</th>
<th>Sustainable Plant Systems (Seminar)</th>
<th>Z Dr</th>
<th>2 credits</th>
<th>2S</th>
<th>M. Paschke, S. F. Bender, G. S. Bhullar, F. Liebisch, further lecturers</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Participants will be able to:</td>
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<td><strong>Objective</strong></td>
<td>(1) Review issues of sustainability in the context of plant science research and literature on sustainable agriculture and the food system.</td>
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<td><strong>Content</strong></td>
<td>(2) Analyze and interact on several case studies in agro-ecology and the food system.</td>
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<td><strong>Content</strong></td>
<td>Future society has to feed nine billion people, therefore agriculture and also food, waste and resource management has to go hand in hand in the use of less resources. We discuss current plant science research in the context of sustainability.</td>
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<td><strong>Focus of the seminar will be on:</strong></td>
<td>(1) Research on agro-ecological systems and farming system research. Can we transform the impact of our agricultural practices below the planetary boundaries? Where does current research indicate on directions for current practice?</td>
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<td><strong>Focus of the seminar will be on:</strong></td>
<td>(2) The Sustainable Development Goals that should guide the current contributions of plant sciences: What research and innovation are necessary to contribute to the SDGs?</td>
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<td><strong>Focus of the seminar will be on:</strong></td>
<td>(3) Building sustainable food systems: How could local food systems be build and scaled up? In this topic, our focus is on giving insight in policy strategies and local sustainability efforts to give the group of participants an opportunity to understand sustainability in the local societal context.</td>
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<td><strong>The course will be organized with two workshops (half days, 14:00 - 18:00) and an intensive, well-structured self-study group work phase in between the workshops.</strong></td>
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<td><strong>Online learning material is for example provided on:</strong></td>
<td>• Nitrogen supply in tropical low input conservation agriculture</td>
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<tr>
<td><strong>Online learning material is for example provided on:</strong></td>
<td>• Nitrous oxide emissions from agriculture</td>
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<tr>
<td><strong>Online learning material is for example provided on:</strong></td>
<td>• Role of vascular plants in methane emissions from soil</td>
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<tr>
<td><strong>Online learning material is for example provided on:</strong></td>
<td>• Mycorrhizal symbioses for soil nutrient management in agro-ecosystems</td>
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<tr>
<td><strong>Case Studies:</strong></td>
<td>How do you farm sustainably?</td>
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<tr>
<td><strong>Case Studies:</strong></td>
<td>What influence do the consumers in developed (importing) countries have on sustainability of (mainly) small-holder farming in the developing (sourcing) countries?</td>
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<tr>
<td><strong>Case Studies:</strong></td>
<td>How can Swiss farmers move to zero environmental impact?</td>
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<tr>
<td><strong>Case Studies:</strong></td>
<td>Sensor based fertilization techniques for sustainability?</td>
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<tr>
<td><strong>Case Studies:</strong></td>
<td>The sustainable development goals (SDG) and sustainable urban food systems.</td>
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<tr>
<td><strong>Case Studies:</strong></td>
<td>More information: <a href="https://www.plantsciences.uzh.ch/en/teaching/masters/sustplantsys.html">https://www.plantsciences.uzh.ch/en/teaching/masters/sustplantsys.html</a></td>
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<td><strong>Access to the learning platform:</strong></td>
<td><a href="https://lms.uzh.ch/auth/RepositoryEntry/3604873218/CourseNode/83441794245107">https://lms.uzh.ch/auth/RepositoryEntry/3604873218/CourseNode/83441794245107</a> (use your AAI login)</td>
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<tr>
<td><strong>Subject-specific Competencies</strong></td>
<td>Concepts and Theories</td>
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<tr>
<td><strong>Method-specific Competencies</strong></td>
<td>Analytical Competencies</td>
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<tr>
<td><strong>Social Competencies</strong></td>
<td>Communication</td>
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<td><strong>Personal Competencies</strong></td>
<td>Critical Thinking</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Taught competencies</td>
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<tr>
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<table>
<thead>
<tr>
<th>551-0120-00L</th>
<th>Plant Biology Colloquium (Autumn Semester)</th>
<th>Z</th>
<th>2 credits</th>
<th>1K</th>
<th>S. C. Zeeman, K. Bombilies, C. Sánchez-Rodríguez, O. Voinnet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This compulsory course is required only once. It may be taken in autumn as course 551-0120-00 “Plant Biology Colloquium (Autumn Semester)” or in spring as course 551-0120-01 “Plant Biology Colloquium (Spring Semester)”.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Current topics in Molecular Plant Biology presented by internal and external speakers from accademia.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Getting insight into actual areas and challenges of Molecular Plant Biology.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Students must sign up via secr.micro.biol.ethz.ch</td>
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<td><strong>Taught competencies</strong></td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 243 of 2345
NMR Methods for Studies of Biological Macromolecules

Prerequisites: Basic knowledge in biological NMR spectroscopy.

Abstract
Seminar series on technical aspects of high resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.

Objective
Introduction and discussion of advanced methods for recording and analysis of NMR data with biological macromolecules.

Content
Seminar series on technical aspects of high-resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.

Current Topics in Molecular Health Sciences

Prerequisites / notice
Approval of the responsible lecturer necessary for participation

Abstract
This course is a seminar series on current research topics within the Institute of Molecular Health Sciences and is targeted at Master students and PhD students conducting research projects in the field of molecular health sciences.

Objective
The course introduces the participants to recent developments in the fields of molecular health sciences.

Content
The course introduces the participants to recent developments in the fields of molecular health sciences.

Lecture Series: Space Research and Exploration

Prerequisites / notice
(List of speakers will be made available in due time)

Abstract
Lecture Series about topics of space research and exploration consisting of individual talks given by different leading experts from industry and academia.

Objective
Attending students will
- experience the interdisciplinarity of space research and exploration spanning physics, engineering, geosciences, biology and more
- get familiar with the Swiss space research and industry sector
- improve their report writing skills by reflecting on one of the talks
- enhance their communication skills by broadening their research horizon
- have the opportunity for direct learning by posing questions to experts

Content
The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The 'Lecture Series: Space Research and Exploration' aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lecture, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.
Biology Bachelor

▸ Bachelor Studies (Programme Regulations 2020)
▸▸ First Year Courses
▸▸▸ First Year Examinations
▸▸▸▸ First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>551-0125-00L</td>
<td>Fundamentals of Biology I: From Molecules to the Biochemistry of Cells</td>
<td>O</td>
<td>6 credits</td>
<td>5G</td>
<td>J. Vorholt-Zambelli, N. Ban, R. Glockshuber, K. Locher, J. Piel</td>
</tr>
</tbody>
</table>

Abstract
The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

Objective
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biochemistry are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

Lecture notes
The newly conceived lecture is supported by scripts.

Literature
The lecture is supported by scripts. The lecture contains elements of "Brock Biology of Microorganisms", Madigan et al. 15th edition, Pearson und "Biochemistry" (Stryer), Berg et al. 9th edition, Macmillan international.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-1001-01L</td>
<td>General Chemistry (for Biol./Pharm.Sc.)</td>
<td>O</td>
<td>4 credits</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
</tbody>
</table>

Abstract
The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.

Objective
The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.

Literature

Weiterführende Literatur:

Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005 (englisch)

Taught competencies

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving not assessed
Project Management not assessed

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

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

529-1011-00L | Organic Chemistry I (for Biol./Pharm.Sc./HST) | O | 4 credits | 4G | C. Thilgen |

Abstract
Fundamentals of Organic Chemistry: molecular structure. Bonding and functional groups; nomenclature; resonance and aromaticity; stereochemistry; conformation; bond strength; organic acids and bases; basic reaction thermodynamics and kinetics; reactive intermediates: carbanions, carbenium ions and radicals.

Objective
Understanding the basic concepts and definitions of organic chemistry. Knowledge of the functional groups and classes of compounds that are important in biological systems. Foundations for the understanding of the relationship between structure and reactivity.

Content
Lecture notes
Printed lecture notes are available. Exercises, answer keys and other handouts can be downloaded from the Moodle course "Organic
Chemistry I" of the current semester (https://moodle-app2.let.ethz.ch).

Literature
· Basisbuch Organische Chemie. Carsten Schmuck, Pearson Studium, 2018. (Kompaktes Lehrbuch für die ersten beiden Semester; 412
Seiten).
· Organic Chemistry I as a Second Language – Translating the basic concepts (Taschenbuch mit Übungen: 400 Seiten). David R. Klein;

Prerequisites / notice
The course consists of lectures (36 hours) and problem-solving lessons (20 hours, groups of ca. 25 people). In addition, online exercises
are available in the e-learning environment Moodle (Course OC I).

Taught competencies

Subject-specific Competencies
Concepts and Theories
assessed

Method-specific Competencies
Analytical Competencies
assessed

Social Competencies
Communication
not assessed

Problem-solving
assessed

Personal Competencies
Creativity
not assessed

Critical Thinking
not assessed

Integrity and Work Ethics
not assessed

Self-awareness and Self-reflection
not assessed

Self-direction and Self-management
not assessed

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0073-00L</td>
<td>Physics I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+2U</td>
<td>T. M. Ihn</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics and elements of quantum mechanics

Objective
Students know and understand the basic ideas of the scientific description of nature. They understand the fundamental concepts and laws of mechanics and they are able to apply them in practical problems. They know the concepts of quantization and quantum numbers.

Content
1. Description of Motion
2. The laws of Newton
3. Work and energy
4. Collision problems
5. Wave properties of particles
6. The atomic structure of matter

Lecture notes
T. Ihn: Physics for Students in Biology and Pharmaceutical Sciences (unpublished lecture notes)

Literature

Feynman, Leighton, Sands, "The Feynman Lectures on Physics", Volume I (http://www.feynmanlectures.caltech.edu/)

Subject-specific Competencies
Concepts and Theories
assessed

Method-specific Competencies
Analytical Competencies
assessed

Social Competencies
Cooperation and Teamwork
not assessed

Problem-solving
assessed

Personal Competencies
Critical Thinking
assessed

Self-awareness and Self-reflection
not assessed

Self-direction and Self-management
not assessed

401-0291-00L| Mathematics I                | O    | 6 credits | 4V+2U | E. W. Farkas |

Abstract
Mathematics I/II is an introduction to one- and multidimensional calculus and linear algebra emphasizing on applications.

Objective
Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences. Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems.
## Eindimensionale diskrete Entwicklungen ##
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsrate
- Folgen und Grenzwerte

## Funktionen in einer Variablen ##
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

## Differentialechnung (I) ##
- Veränderungsrate/-geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

## Integralrechnung (I) ##
- Stammfunktionen
- Integrationstechniken

## Gewöhnliche Differentialgleichungen (I) ##
- Qualitative Beschreibung an Beispielen: Beschränkt, Logistisch, Gompertz
- Stationäre Lösungen
- Lineare DGL 1. Ordnung
- Trennung der Variablen

## Lineare Algebra ##
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

Lecture notes
In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:

* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature
Siehe auch Lernmaterial > Literatur

**L. Papula**
Mathematik für Ingenieure und Naturwissenschaftler, 2 Bände; Springer Verlag Vieweg.
Via ETHZ-Bibliothek:

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände: Einführung in die Analysis, Einführung in die Lineare Algebra; Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF auch als [pdf](https://people.math.ethz.ch/~blatter/linalg.pdf)

Prerequisites / notice

## Übungen und Prüfungen ##
+ Die Übungsaufgaben (inkl. Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltung.
+ Es wird erwartet, dass Sie mindestens 75 % der wöchentlichen Serien bearbeiten und zur Korrektur einreichen.
+ Der Prüfungssstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

### First Year Laboratory Courses ###

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-1001-00L</td>
<td>Laboratory Course General Chemistry (for Biology and Pharmacy)</td>
<td>O</td>
<td>6 credits</td>
<td>8P</td>
<td>S. Gruber, J. Hall</td>
</tr>
</tbody>
</table>

Register in myStudies as early as possible, because the fire protection courses take place separately before the internship starts.

Abstract
Introduction to the practical work in a chemistry laboratory. The most important manipulations and techniques are treated, as well as the most fundamental chemical reaction types.
Objective
- Knowledge of the basic chemical laboratory methods
- Basic knowledge of the scientific approach in experimenting
- Observation and interpretation of chemical processes
- Keeping of a reliable laboratory journal

Content
- Simple chemical working techniques/methods
- Separation techniques
- Physical measurements: mass, volume, pH
- Ionic solids (salts)
- Acid/base chemistry, buffers
- Redox reactions
- Metal complexes
- Titration methods and quantitative spectrometry
- Introduction to qualitative analysis

Lecture notes
Course manual in German (is handed out to the students at the begin of the lessons)
Language: German, English upon request

Literature
Wiley

is a suitable textbook.

Prerequisites / notice
This practical course causes costs for materials and chemicals. The costs are charged to the students at the end of semester.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

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### Second Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0127-00L</td>
<td>Fundamentals of Biology III: Multicellularity</td>
<td>O</td>
<td>8</td>
<td>6G</td>
<td>M. Stoffel, M. Künzler, O. Y. Martin,</td>
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<tr>
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<td>U. Suter, S. Werner, A. Wutz, S. C. Zeeman</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture conveys the fundamental concepts underlying multicellularity with an emphasis on the molecular basis of multicellular biological systems and their functional integration into coherent wholes. The structural and functional specialization in multicellular organisms will be discussed by highlighting common and specific functions in fungi, plants, and animals (including humans).</td>
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</tbody>
</table>
| Objective | 1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity.  
2. Students can explain how the internal and external structures of fungi, plants and animals function to support survival, growth, behavior, and reproduction.  
3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development).  
4. Students can describe how a single cell develops from one cell into many, each with different specialized functions. |
| Content   | The lecture introduces the structural and functional specialization in fungi, plants and animals, including humans. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi, plants, animals and humans have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, human anatomy and physiology, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development. |
|           | Campbell “Biology”, 11th Edition |

Prerequisites / notice
Some lecture are held in English.

| 551-1005-00L | Bioanalytics                       | O    | 4    | 4G    | P. Picotti, F. Allain, V. Korkhov,            |
|              |                                |      |      |       | M. Pilhofer, R. Schlapbach, K. Weis,         |
|              |                                |      |      |       | K. Wüthrich, further lecturers               |
| Abstract    | The course will introduce students to a selected set of laboratory techniques that are foundational to modern biological research. |
| Objective   | For each of the techniques covered in the course, the students will be able to explain: a) the physical, chemical and biological principles underlying the technique, b) the requirements for the sample, c) the type of raw data collected by the technique, d) the assumptions and auxiliary information used in the interpretation of the data and e) how these data can be used to answer a given biological question. By the end of the course the students will be able to select the appropriate experimental technique to answer a given biological problem and will be able to discuss the advantages and limitations of individual techniques as well as how different techniques can be combined to gain a more complete understanding of a given biological questions. |
| Content     | The course will be based on a combination of lectures, selfstudy elements and exercises. The focus will be on the following experimental techniques: DNA sequencing, chromatography, mass-spectrometry, UV/Vis and fluorescence spectrometry, light microscopy, electron microscopy, X-ray crystallography, NMR spectroscopy. |
| Lecture notes | The course is supported by a Moodle page that gives access to all supporting materials necessary for the course. |
The following topics are covered: modeling and simulations, introduction to programming, introduction matrices, managing data with lists and tables and with relational databases, universal methods for algorithm design.

The students learn to:
- understand the role of computer science in science,
- to control computer and automate processes of problem solving by programming,
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

Content
1. The role of computer science in science
2. Introduction to Programming with Python
3. Modeling and simulations
4. Data management with lists and tables
5. Data management with a relational database
6. Introduction to Matrices

Lecture notes
All materials for the lecture are available at www.gdi.ethz.ch

Literature

Prerequisites / notice
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.
In addition to the lecture script, the following two books can be used to gain deeper understanding:


Subject-specific Competencies

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<th>Concepts and Theories</th>
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<tr>
<td>Techniques and Technologies</td>
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Method-specific Competencies

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<tr>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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Social Competencies

<table>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Lecture notes

Documentation will be handed out at the beginning of the course.

Literature

1) P. Wörfel, M. Bitzer, U. Claus, H. Felber, M. Hübel, B. Vollenweider, *Laborpraxis* (Bd. 1: Einführung, allgemeine Methoden; Bd. 2: Messmethoden; Bd. 3: Trennungsmethoden; Bd. 4: Analytische Methoden); Birkhäuser Verlag; Basel; 1990.


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Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Lecture notes

Documentation will be handed out at the beginning of the course.
Abstract
The concept course "Evolutionary Genetics" consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Objective
The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content
Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.
Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem.
Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation

Lecture notes
Handouts

Literature

551-0307-00L Molecular and Structural Biology I: Protein Structure and Function
Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH.

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman

Current topics: References will be given during the lectures.

551-0309-00L Concepts in Modern Genetics
Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH.

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

551-0311-00L Molecular Life of Plants

Abstract
The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.

Objective
The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.
The course "Molecular Life of Plants" will cover the following topics:

- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
- Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses

551-0313-00L Microbiology (Part I) W 3 credits 2V W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad

Abstract Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective This concept class will be based on common concepts and introduce the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes Updated handouts will be provided during the class.

Literature Current literature references will be provided during the lectures.

Prerequisites / notice The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

551-0319-00L Cellular Biochemistry (Part I) W 3 credits 2V U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp

Abstract Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

551-0317-00L Immunology I W 3 credits 2V M. Kopf, A. Oxenius

Abstract Introduction into structural and functional aspects of the immune system.

Objective Introduction into structural and functional aspects of the immune system.

Content Basic knowledge of the mechanisms and the regulation of an immune response.

- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature - Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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</tr>
<tr>
<td></td>
<td>Decision-making</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
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<tr>
<td></td>
<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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### 551-1299-00L Bioinformatics

**Number**: 529-0731-00L

**Title**: Nucleic Acids and Carbohydrates

**ECTS**: 6 credits

**Type**: W

**Lecturers**: S. Sunagawa, P. Beltrao, A. Blasimme, A. Kahles, C. von Mering, N. Zamboni

**Prerequisites / notice**

Course participants have already acquired basic programming skills in Python and R.

**Abstract**

Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, bioinformatics, and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

**Objective**

Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

**Literature**

Mainly based on original literature, a detailed list will be distributed during the lecture

**Taught competencies**

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### Block Courses


Please note the ETH admission criteria for the admission of ETH students to ETH block courses on the block course registration website under "allocation".

### Block Courses in 1st Quarter of the Semester

**20.9.2022 - 12.10.2022**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>551-1129-00L</td>
<td>Understanding and Engineering Microbial Metabolism</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>J. Vorholt-Zambelli</td>
</tr>
</tbody>
</table>

**Abstract**

This laboratory course has a focus on current research topics in our laboratory related to metabolic engineering, the general understanding of metabolism, and is partially focused on one carbon metabolism. Projects will be conducted in small groups.
The course aims at introducing technologies to investigate bacterial metabolism and key principles of metabolic engineering. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular genetic, biochemical and analytical techniques including metabolomics. Results will be presented by students in scientific presentations. Another goal is to learn to write a scientific report.

Experimental work applied during the course will comprise methods such as cloning work & transformation, growth determination, enzyme activity assays, liquid-chromatography mass-spectrometry and dynamic labeling experiments.

**Objective**

- Participants will be tutored in their experimental work by an experienced doctoral student.
- The course will also include a short lecture delivered by M. Hospenthal, providing the theoretical background for the experimental work.
- Throughout the course, students will receive exercises that further help to explain the theory of the practical work, as well as literature research tasks.
- Participation in the following Hospenthal lab projects will be possible:
  - Purification, biophysical characterisation and structure determination of pilins
  - Purification, biophysical characterisation and structure determination of proteins and protein complexes involved in natural transformation
  - Experimental work on this project involves:
    - Cloning and mutagenesis
    - Recombinant or endogenous protein production in E. coli or Legionella
    - Protein purification by affinity chromatography (other chromatographic purification techniques will also be discussed)
    - Protein crystallisation and crystal optimisation
    - Visualisation of bacterial pil by electron microscopy (negative stain or cryo electron microscopy)
    - DNA binding experiments
    - Enzymatic activity measurements
  - In silico structural analyses using PyMOL and Chimera
  - Literature
    - Any required reading of literature will be discussed at the beginning of the course.
  - Prerequisites / notice
    - There are no special requirements for this course.
  - Literature
    - Lecture notes
    - Literature
    - Relevance and recommended literature (review articles) will be provided during the course.

**Content**

- Students will carry out defined research projects related to the current research topics of the Hospenthal group. The topics will include protein expression of pilins and/or other competence proteins from Gram-negative bacteria, protein purification using affinity chromatography, crystallisation experiments and analysis of assembled pil by electron microscopy.
- The course should enable students to understand concepts of protein expression, purification and the characterisation of biomolecular interactions. In addition, students will learn some basic principles of X-ray crystallography and electron microscopy.
- The students will be tutored in their experimental work by an experienced doctoral student. The course will also include a short lecture delivered by M. Hospenthal, providing the theoretical background for the experimental work. Throughout the course, students will receive exercises that further help to explain the theory of the practical work, as well as literature research tasks.

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<th>Prerequisites</th>
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<tr>
<td>551-1415-00L</td>
<td>The Mechanics of Natural Transformation in Competent Gram-Negative Bacteria</td>
<td>W</td>
<td>6</td>
<td>B. Snijder, further lecturers</td>
</tr>
<tr>
<td>551-0337-00L</td>
<td>Cell Biology of the Nucleus</td>
<td>W</td>
<td>6</td>
<td>R. Kroschewski, Y. Barral, M. Jagannathan, S. Jessberger, K. Weis</td>
</tr>
<tr>
<td>551-1421-00L</td>
<td>Image-Based Drug Screening in Human Blood for Personalized Medicine</td>
<td>W</td>
<td>6</td>
<td></td>
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</tbody>
</table>
The students will work on a research project focusing on the discovery of bioactive natural products from regional blue-green algae known as cyanobacteria. This course will consider the pathogenetic landscape of cancer and its progression to metastasis, explore how abnormalities of cellular information management cause cancer and demonstrate how the integrated application of modern profiling technologies, mouse cancer models and human pathology provides a foundation for developing individualized cancer therapeutics. Insights into and overview about the genetic and metabolic alterations that underlie different cancer types, the complex cancer cell circuitries governing tumor development, progression, and metastasis. Understanding of modern approaches used in contemporary basic translational cancer research and sophisticated strategies to control individual cancers and combat drug resistance. The course is closely linked to ongoing research projects in the lab to provide the participants with direct insights into current experimental approaches and strategies. Student assessment is a graded performance based on individual performance in the laboratory, a written report of their data and a presentation of a recent paper published in a top ranking international peer reviewed journal that relates to cancer.

**Discovery of Drugs from Blue-Green Algae**

**Objective**

The students will receive an introduction to relevant subjects of the secondary metabolism of bacteria. Lectures will include an introduction to blue-green algae natural history, systems and distribution, natural products and drug discovery, bioprospecting and industrial fermentation, relevant analytical methods, microbial communities and metagenomics. The students will receive training in practical work in a research laboratory as well as scientific literacy skills in the form of a research report and oral presentation.

**Content**

The students will work on a research project focusing on the discovery of bioactive natural products from regional blue-green algae known to produce bioactive molecules. Students will learn from lectures in class, lab and in the field and gain experience with field collection techniques and the sequence of steps required for natural products discovery including organic extraction, fractionation, and column chromatography. They will use analytical techniques such as HPLC and mass spectrometry for initial characterization of the purified secondary metabolites. Primary biological assays will be conducted to identify natural product extracts and fractions with antibiotic activity as a first step in the drug discovery process.

**Prerequisites / notice**

Additional materials will be provided before the start of the course.

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**Introduction to Mass Spectrometry-Based Proteomics**

**Objective**

How to prepare a protein sample for MS analysis (trypsin digestion, C18 clean-up) Principles of data acquisition LC-MS (QTOF and/or Ion Trap instruments) Perform quantitative proteomic analysis (protein identification with Mascot and/or Sequest Softwares) Perform qualitative proteomic analysis (label-free and labeled analyses) Analyze/interpret the data to find up/down regulated proteins

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**Block Courses in 2nd Quarter of the Semester**

**Introduction of the biological and ecological basics of fungi in forests.**

Introduction to the structural and functional diversity of the fungal kingdom. Focus on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures. Knowledge of fungi and its ecological significance. Knowing of current methodological research approaches. Self-reliant and deepened abilities of selected topics of fungi from forests. Introduction of the biological and ecological basics of fungi in forests. Focus on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

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**Membrane Biology**

**Objective**

The enrolment is done by the D-BIOL study administration.

**Prerequisites / notice**

Der Blockkurs findet an der Eidg. Forschungsanstalt WSL in Birmensdorf statt. Der Wald vor der Haustüre des Institutes macht diesen Kurs besonders praxisnah. Erreichbarkeit mit Tram 14 bis Triemli, danach PTT-Bus 220 oder 350 bis Birmensdorf Sternen/WSL, oder mit S9 bis Birmensdorf SBB und mit PTT-Bus eine Station in Richtung Zürich bis Birmensdorf Sternen/WSL.

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**Membrane Biology**

**Objective**

The enrolment is done by the D-BIOL study administration.

**Prerequisites / notice**

Erreichbarkeit mit Tram 14 bis Triemli, danach PTT-Bus 220 oder 350 bis Birmensdorf Sternen/WSL, oder mit S9 bis Birmensdorf SBB und mit PTT-Bus eine Station in Richtung Zürich bis Birmensdorf Sternen/WSL.
The course will introduce the students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course.

Objectives The aim of the course is to expose the students to a wide range of modern research areas encompassed by the field of membrane biology, and to equip them with the skills necessary to design and perform experiments on their own. Students will be encouraged to develop their research skills and to contribute to the current body of knowledge in the field.

Content Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field.

Lecture notes No script

Literature The recommended literature, including reviews and primary research articles, will be provided during the course.

Prerequisites / notice The course will be taught in English. All general lectures will be held at ETH Hoenggerberg. Students will be divided into small groups to carry out experiments at ETH or at the Paul Scherrer Institute. Travel to the Paul Scherrer Institute will be by public transportation.

551-1201-00L Computational Methods in Genome and Sequence Analysis

Objective The enrolment is done by the D-BIOL study administration.

Abstract This course aims to provide students with a comprehensive overview of computational methods for sequence analysis and assist with developing skills for the application of computational approaches by experimental scientists in the life sciences.

Content
- Understanding the information in biological sequences and quantifying similarity
- Introduction to algorithms for sequence comparison and searches
- Implementation of sequence comparisons and searches in Python
- Accessing data formats associated with genome sequence analysis tasks
- Understanding the anatomy of a real world sequence analysis project
- Applying tools for sequence alignment and estimating error rates
- Ability to implement a solution to a problem in sequence analysis using Python
- Accessing genome annotation and retrieving relevant information in Pandas
- Application of Genomic intervals and arrays for sequence analysis with HTSeq

Prerequisites / notice
- It is recommended to bring your own computer with a Python installation to the course
- Simple computers can be provided
- Programming basics with Python

551-1143-00L Analysis of Human T and B Cell Responses to Infectious Agents

Objective The enrolment is done by the D-BIOL study administration.

Abstract Students actively participate in ongoing research projects on the analysis of human T and B cell response to pathogens and vaccines. They will be tutored in small groups by doctoral students and postdocs. In a lecture series, the theoretical background for the projects will be provided and the students will have the opportunity to present their projects and discuss recent publications.

Content
- Introduction to current concepts through lectures and discussion of original papers. Requirement for obtaining the credit points: oral presentation of the research project in a ppt format.
- Participation in a project from the following list is possible: 1) Photosynthesis: How is photosynthesis regulated and how is photoassimilated carbon distributed in plants? 2) Biology of chloroplasts: How do chloroplasts develop and how is their function coordinated with that of the whole cell? 3) Starch biosynthesis and degradation: How are complex, semi-crystalline starch granules produced from monosaccharides and how are they broken down again to release energy?

Lecture notes No script

Literature Descriptions of the possible projects including individual reading suggestions will be handed out beforehand.

551-0359-00L Plant Biochemistry

Objective The enrolment is done by the D-BIOL study administration.

Abstract In this block course, students actively participate in ongoing research projects on plant metabolism and are tutored by doctoral students and postdocs. The theoretical background of the projects is provided in a lecture series. Finally, students discuss their projects and results during an interactive poster session.

Content
- Through supervision in small groups (either individually or in groups of two) students learn to conduct experiments in molecular plant biology, interpret the results, record them and communicate them to peers. Students also gain an insight into the larger context of their projects and how they are planned in the longer term.
- Participation in a project from the following list is possible: 1) Photosynthesis: How is photosynthesis regulated and how is photoassimilated carbon distributed in plants? 2) Biology of chloroplasts: How do chloroplasts develop and how is their function coordinated with that of the whole cell? 3) Starch biosynthesis and degradation: How are complex, semi-crystalline starch granules produced from monosaccharides and how are they broken down again to release energy?

Lecture notes No script

Literature Descriptions of the possible projects including individual reading suggestions will be handed out beforehand.

551-0345-00L Mechanisms of Bacterial Pathogenesis

Objective The enrolment is done by the D-BIOL study administration.

Abstract Research laboratory class in small groups. Research projects on current topics in cellular microbiology and bacterial pathogenesis are assigned to each student.

Content
- Introduction to a current topic in cellular microbiology and/or molecular genetics of a bacterial pathogen. Experimental work in the research lab and introduction to the current lab techniques. This includes contributions to the analysis of animal experiment. You will work with the current research literature in bacterial pathogenesis and write a research protocol.
- Requirement for obtaining the credit points: oral presentation of the research project, a short written exam and evaluation of the research protocol.
- Research projects on the model pathogen Salmonella.
ECTS: 6 credits

All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

Prerequisites / notice

This laboratory course will involve experiments that require a tight schedule and, particularly in the second half, very long (!) working days. The enrolment is done by the D-BIOL study administration.

Number of participants limited to 12. The enrolment is done by the D-BIOL study administration.

Abstract

Fundamentals (theoretical and practical) in phytopathology, eg. interaction between plants and plant-pathogenic microorganisms, morphology and lifecycles of plant-pathogenic fungi, evolution of plant-pathogenic fungi, biological control of plant diseases

Objective

Fundamentals (theoretical and practical) in phytopathology, eg. interaction between plants and plant-pathogenic microorganisms, morphology and lifecycles of plant-pathogenic fungi, evolution of plant-pathogenic fungi, biological control of plant diseases

Content

Experiments within ongoing phytopathological research projects

Macro- and microscopic diagnostic of plant diseases

Theoretical courses:

Fundamentals of phytopathology, eg. interaction between plants and plant-pathogenic microorganisms, morphology and lifecycles of plant-pathogenic fungi, evolution of plant-pathogenic fungi, biological control of plant diseases

Teaching language is english and german.

The course will be taught partly in English, partly in German.

Prerequisites

The course will be distributed at the beginning of the course

Lecture notes

A script will be distributed to the participants on the first day of the course.

Literature

General literature to "Directed Evolution" and chorismate mutases, e.g.:


Further literature will be indicated in the distributed script.

Prerequisites / notice

This laboratory course will involve experiments that require a tight schedule and, particularly in the second half, very long (!) working days. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html
Methods in Cellular Biochemistry

Number of participants limited to 13.

The enrolment is done by the D-BIOL study administration.

Abstract

Students will learn about biochemical approaches to analyze cellular functions. The course consists of practical projects in small groups, lectures and literature discussions. The course concludes with the presentation of results at a poster session.

Objective

Students will learn to design, carry out and assess experiments using current biochemical and cell biological strategies to analyze cellular functions in model systems. In particular they will learn novel imaging techniques along with biochemical approaches to understand fundamental cellular pathways. Furthermore, they will learn to assess strengths and limitations of the different approaches and be able to discuss their validity for the analysis of cellular functions.

Literature

Documentation and recommended literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

This course will be taught in English.

Insulin Signaling

Number of participants limited to 15.

The enrolment is done by the D-BIOL study administration.

Abstract

Introduction to the physiological and biochemical action of insulin signaling and its role in the fasted/feeding response and in obesity and diabetes.

Objective

The students will obtain an overview about the current topics of research in insulin signaling and how it impacts on growth, metabolism and cell differentiation. They will learn to design experiments and use techniques necessary to analyze different aspects of insulin signaling, including physiological actions in whole animals as well as in tissue culture. Through lectures and literature seminars, they will learn about the open questions of insulin signaling research and discuss approaches to address these questions experimentally.

In practical lab projects the students will perform physiological in vivo studies as well as biochemical experiments. Finally, they will learn how to present and discuss their data. Student assessment is a graded semester performance based on individual performance in the laboratory, a written exam and the lab data presentation.

Experimental Food Microbiology for Biologists

Number of participants limited to 12

Prerequisites: It is recommended to attend the course Lebensmittel-Mikrobiologie (752-4005-00L) as a preparation.

The course can only be booked via the Biology Student secretariat.

Abstract

Teaching of basic experimental knowledge for detection and identification of microorganisms in food. Practical experiments were accompanied by theoretical introductions. Students become acquainted with classical and state-of-the-art molecular techniques for the rapid detection of foodborne pathogens and experiments in dependence on current research topics of the Laboratory of Food Microbiology.

Objective

Introduction of methods and techniques of food microbiology

Content

Teaching of basic experimental knowledge for detection and identification of foodborne pathogens by applying state-of-the-art techniques as well as modern molecular techniques for the rapid identification of relevant foodborne pathogens.

Lecture notes

Handouts were provided at the start of the course

Literature

- Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- Süßmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

Prerequisites / notice

Important information!

During the course we will work with the food-borne pathogen Listeria monocytogenes. Listeria monocytogenes represents a particular threat to pregnant women. Due to biosafety reasons participation is not allowed in case of pregnancy.

Protein Change in Adaptive Evolution

Number of participants limited to 5.

The enrolment is done by the D-BIOL study administration.

Abstract

Proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.

Objective

To learn techniques in protein structure prediction, functional prediction and evolutionary analyses (bioinformatic), as well as protein purification from e. coli, insect cell, and/or cell-free systems, and analysis of e.g. interactions with DNA, thermostability, etc…

Content

Guided research projects to study the biochemical consequences of adaptive evolution in a variety of proteins. Mostly the focus is on proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.

Lecture notes

Will be provided, as appropriate, during the course.

Literature

Will be provided during course.

Microbial Community Genomics

Number of participants limited to 10.

Prerequisite: Basic knowledge in R (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer.

The enrolment is done by the D-BIOL study administration.

Abstract

Introduction to current research methods in the analysis of microbial communities using Next Generation Sequencing approaches - metagenomics. Practical experience of work in a computational laboratory and an introduction to scientific programming.
This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer.

To learn modern technologies in Molecular and Cellular Biology as well as Histology and to use these techniques to study questions related to mechanisms underlying tissue repair and cancer.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 20.

The enrolment is done by the D-BIOL study administration.

This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer.

The enrolment is done by the D-BIOL study administration.

The goal is to acquire the techniques to image bacteria by electron cryotomography, resolving their structure in a native state, in 3D, and to understand tips and tricks in high-resolution imaging. Students will learn to design experiments and use techniques to solve different problems addressed.

The course combines practical work with lectures, discussions, project preparations and presentations.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 15.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 17.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 16.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 20.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 10.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 16.

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Number of participants limited to 17.

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Number of participants limited to 16.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 15.

The enrolment is done by the D-BIOL study administration.

Number of participants limited to 10.

Objectives
Gain skills in data analysis and presentation for oral and written reports. Lectures introducing state-of-the-art in respective research areas and community microbiology, which is the target of ongoing research. Start to assess current literature.

Prerequisites / notice
Basic knowledge in R (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer.

Abstract
Lab course. In small groups projects of relevance to current research questions in the field of bacterial natural product biosynthesis are addressed.

Objective
Introduction to relevant subjects of the secondary metabolism of bacteria. Training in practical work in a research laboratory. Scientific writing in form of a research report.

Content
Research project on bacteria that produce bioactive natural products (e.g., Streptomycetes, Cyanobacteria, uncultivated bacteria). The techniques used will depend on the project, e.g. PCR, cloning, natural product analysis, precursor feeding studies, enzyme expression and analysis.

Literature

Prerequisites / notice
Students have to present a poster on a special topic.

Number of participants limited to 10.

Number of participants limited to 17.

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Number of participants limited to 20.
Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. In this block course, we study dynein motor proteins in cilia. Dynein causes conformational change upon ATP hydrolysis and finally generate ciliary bending motion. Participants will analyze cryo-EM data of cilia and visualize in vivo 3D structure of dynein to learn how motor proteins function in the cell.

The goal of this course is to familiarize students with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies on motor proteins. The main focus is 3D image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.

Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. Their function is essential for intracellular transport, muscle contraction and other cellular motility as well as cell division. Motor proteins have been major targets of biophysical studies. There exist questions from atomic to tissue levels – how ATP hydrolysis causes conformational change of motor proteins; how their motion is regulated by calcium, phosphorylation and other factors; how motions of multiple motor proteins are coordinated to generate cellular motility. Structural biology has been playing central roles to answer these questions. X-ray crystallography and single particle cryo-EM address structural analysis at atomic resolution and try to reveal molecular mechanism of conformational change. Cryo-electron tomography analyze localization and 3D structure of motor proteins in the cell to explain how motions of molecular motors happen in the context of cellular environment and are integrated into cellular motion. In this course, we will learn to handle aggregation-prone peptides, characterize their aggregation state and structure as well as assemble their ability to template their own chemical synthesis.

During the block course, each student will learn how to handle aggregation-prone peptides, characterize their aggregation state and structure as well as asssemble their ability to template their own chemical synthesis. The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dyneins, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH.

The main focus is 3D image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.

The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dyneins, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH.

The enrolment is done by the D-BIOL study administration. This block course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH.
The course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) and field excursions.

Lecture:
The lecture part covers ecology and evolution of aquatic organisms in lentic and lotic waters. Topics include: Adaptations, distribution patterns, biotic interactions, and conceptual paradigms in freshwater ecosystems; important aspects regarding ecosystem metabolism and habitat properties of freshwaters; applied case studies and experiments testing ecological and evolutionary processes in freshwaters.

Practical part:
The practical part includes an excursion to Greifensee and a 3-day-excursion to the river Glatt in Niederuzwil, where you independently perform small research projects.

Additionally, you will perform in small groups an independent experiment in a research group at Eawag.

The taxonomic part will cover macroinvertebrates (e.g. Crustacean, aquatic insects), microinvertebrates and algae. The goal is to get to know the most common aquatic taxa in Switzerland, to identify them with commonly used identification literature, and to get an idea how these organisms are used in research and practice. (language: German, translation of the most important things during the course possible)

529-0810-01L Laboratory Course Organic Chemistry II
- Admittance is limited and depends on the availability of hosting research labs.
- Interested students are asked to contact Prof. C. Thilgen (thilgen@org.chem.ethz.ch) before the end of the preceding semester for further details.
- In case of admittance, the actual enrolment needs to be done via the D-BIOL study administration.

Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective
Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Lecture notes
No course notes.

Literature
No set textbooks. Literature will be indicated or provided by the supervising TAs.

Notice
The maximal participating number of biology students is 14.

The course includes a field trip to Greifensee (23.09.2021) and a 3-day-excursion to the river Glatt in Niederuzwil from 29.09. to 01.10.2021.

Block Courses in the 2nd Half of the Semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12 credits</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

W: Week

- Admittance is limited and depends on the availability of hosting research labs.
- Interested students are asked to contact Prof. C. Thilgen (thilgen@org.chem.ethz.ch) before the end of the preceding semester for further details.
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Lecture notes
No course notes.

Literature
No set textbooks. Literature will be indicated or provided by the supervising TAs.
Block Courses during the Semester Break

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-1709-00L</td>
<td>Genomic and Genetic Methods in Cell and Developmental Biology</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>A. Wutz, M. Kopf, T. Schroeder</td>
</tr>
</tbody>
</table>

Abstract: This course aims to provide students with a comprehensive overview of mammalian developmental biology and stem cell systems both on the theoretical as well as the experimental level. Centering the course on genetic and genomic methods engages the students in contemporary research and prepares for future studies in the course of semester and master projects.

Objective:
- Understanding mammalian development
- Introduction to stem cell systems
- Working with cultured cells
- Translational aspects of mammalian cell biology

Content: The course will consist of a series of lectures, essay assignments, project development and discussion workshops, and 2 and a half week of lab work with different mammalian cell systems embedded in real life research projects. At the end of the course students will take an exam consisting of questions on the topic of the lectures and workshops. It is expected that students will be able to apply the knowledge to concrete problems.

Bachelor Studies (Programme Regulations 2013)

3. Year, 5. Semester

Concept Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-2413-00L</td>
<td>Evolutionary Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>T. Städler, A. Widmer, S. Fior, M. C. Fischer, J. Stapley</td>
</tr>
</tbody>
</table>

Abstract: The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Objective: The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content: Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Genomic and Genetic Methods in Cell and Developmental Biology: Number of participants limited to 8. The enrolment is done by the D-BIOL study administration.

D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course.

Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.
Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Literature</th>
<th>Basics:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Creighton, T.E., Proteins, Freeman, (1993)</td>
</tr>
<tr>
<td></td>
<td>- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.</td>
</tr>
</tbody>
</table>

551-0309-00L  Concepts in Modern Genetics  
Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Abstract  Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective  This course focuses on the concepts of classical and modern genetics and genomics.

Content  The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes  Scripts and additional material will be provided during the semester.

551-0311-00L  Molecular Life of Plants  

Abstract  The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.

Objective  The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

Content  The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.

Abstract  The course "Molecular Life of Plants" will cover the following topics:

- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
- Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
- Senescence

551-0313-00L  Microbiology (Part I)  

Abstract  Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective  This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content  Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes  Updated handouts will be provided during the class.

Literature  Current literature references will be provided during the lectures.

Prerequisites / notice  English

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

551-0319-00L  Cellular Biochemistry (Part I)  

Abstract  Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective  The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.
Introduction into structural and functional aspects of the immune system. Not assessed

Nucleic Acids and Carbohydrates

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**551-0317-00L Immunology I**

**W 3 credits 2V M. Kopf, A. Oxenius**

**Abstract**
Introduction into structural and functional aspects of the immune system.

Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**
Introduction into structural and functional aspects of the immune system.

**Content**
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

**Literature**
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

**Prerequisites / notice**
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**Taught competencies**

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

**Social Competencies**
Communication, cooperation and teamwork, customer orientation, leadership and responsibility, self-presentation and social influence, sensitivity to diversity, negotiation, adaptability and flexibility, critical thinking, creative thinking, integrity and work ethics, self-awareness and self-reflection, self-direction and self-management.

**Personal Competencies**

- Basic knowledge of the mechanisms and the regulation of an immune response.

**551-1299-00L Bioinformatics**

**W 6 credits 4G S. Sunagawa, P. Beltrao, A. Blasimme, A. Kahles, C. von Mering, N. Zamboni**

**Abstract**
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

**Objective**
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

**Prerequisites / notice**
Course participants have already acquired basic programming skills in Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

**529-0731-00L Nucleic Acids and Carbohydrates**

**W 6 credits 3G K. Lang, P. A. Kast, S. J. Sturla, H. Wennenmers**

**Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.**

**Abstract**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Objective**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Content**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines
Image-Based Drug Screening in Human Blood for Personalized Medicine

Number of participants limited to 5.
The enrolment is done by the D-BIOL study administration.

Abstract
Image-based screening allows to measure in high throughput the phenotype of millions of individual cells to external perturbations. We have recently shown that image-based screening in human blood can help to find active treatments for patients with blood cancers. In this course we will take the students through the entire workflow (to the extent that biosafety regulations allow it).

Objective

- Self-awareness and Self-reflection
- Self-direction and Self-management

Literature

Image-based screening allows to measure in high throughput the phenotype of millions of individual cells to external perturbations. We have recently shown that image-based screening in human blood can help to find active treatments for patients with blood cancers. In this course we will take the students through the entire workflow (to the extent that biosafety regulations allow it).
Objective

Take the students through the entire workflow from experimental design, to screen, to imaging and analysis.

- Learn to design an image-based screening experiment
- Observe human blood sample handling
- Perform immunofluorescence & automated confocal microscopy
- Image analysis and result interpretation
- Result presentation

Literature

- Relevant study: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30208-9/fulltext
- Editorial commentary: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30213-2/fulltext

551-0337-00L

Cell Biology of the Nucleus

Number of participants limited to 18.
The enrolment is done by the D-BIOL study administration.

Abstract

Introduction to the organizational principles of the nucleus using budding yeast, drosophila and vertebrate cells as model systems.

Objective

The aim of our course is to introduce the students to the organizational principles of the nucleus using budding yeast, drosophila and vertebrate cells as model systems. Emphasis is given to:

- Establishment of nuclear identity and nuclear-cytoplasmic communication
- Reorganization of the nucleus in aging
- Animal cells during the generation of cell diversity and neuronal differentiation

Content

By the end of the course, based on lectures, literature reading and practical lab work, the students will be able to formulate open questions concerning the function of the nucleus. Thus, the students will know about the mechanisms and consequences of nuclear-cytoplasmic compartmentalization, nuclear positioning, DNA clustering in the nucleus and cytoplasm during cell divisions and aging.

551-1525-00L

Cancer Progression: Mechanisms, Targets and Therapeutic Approaches

Number of participants limited to 15.
The enrolment is done by the D-BIOL study administration.

Abstract

This course will consider the pathogenetic landscape of cancer and its progression to metastasis, explore how abnormalities of cellular information management cause cancer and demonstrate how the integrated application of modern profiling technologies, mouse cancer models and human pathology provides a foundation for developing individualized cancer therapeutics.

Objective

Insights into and overview about the genetic and metabolic alterations that underlie different cancer types, the complex cancer cell circuitries governing tumor development, progression, and metastasis. Understanding of modern approaches used in contemporary basic and translational cancer research and sophisticated strategies to control individual cancers and combat drug resistance. The course is closely linked to ongoing research projects in the lab to provide the participants with direct insights into current experimental approaches and strategies. Student assessment is a graded performance based on individual performance in the laboratory, a written report of their data and a presentation of a recent paper published in a top ranking international peer reviewed journal that relates to cancer.

551-1149-00L

Discovery of Drugs from Blue-Green Algae

Number of participants limited to 3.
The enrolment is done by the D-BIOL study administration.

Abstract

Natural products have long been used as medicine. Blue-green algae (Cyanobacteria) are particularly renowned for producing compounds with antibacterial, anticancer, and insecticidal properties. In this block course, students explore Switzerland’s algal communities in habitats including lakes, marshes, streams, peat and raised bogs, and alluvial and riverine forests.

Objective

The students will receive an introduction to relevant subjects of the secondary metabolism of bacteria. Lectures will include an introduction to blue-green algae natural history, systematics and distribution, natural products and drug discovery, bioprospecting and industrial fermentation, relevant analytical methods, microbial communities and metagenomics. The students will receive training in practical work in a research laboratory as well as scientific literacy skills in the form of a research report and oral presentation.

Content

The students will work on a research project focusing on the discovery of bioactive natural products from regional blue-green algae known to produce bioactive molecules. Students will learn from lectures in class, lab and in the field and gain experience with field collection techniques and the sequence of steps required for natural products discovery including organic extraction, fractionation, and column chromatography. They will use analytical techniques such as HPLC and mass spectrometry for initial characterization of the purified secondary metabolites. Primary biological assays will be conducted to identify natural product extracts and fractions with antibiotic activity as a first step in the drug discovery process.

Lecture notes

Provided after each lecture.

Literature

https://archive.org/details/howtoknowfreshwat00pres

Additional materials will be provided before the start of the course.

Prerequisites / notice

None

551-0352-00L

Introduction to Mass Spectrometry-Based Proteomics

Number of participants limited to 12.
The enrolment is done by the D-BIOL study administration.

Abstract

Protein Analysis by Mass Spectrometry

The following topics will be covered: basics of biological mass spectrometry, including instrumentation, data collection and data analysis; applications to protein identification and characterization; sample preparation methods; proteomics strategies; and quantitative analysis.
Objective
How to prepare a protein sample for MS analysis (trypsin digestion, C18 clean-up)
Principles of data acquisition LC-MS (QTOF and/or Ion Trap instruments)
Perform qualitative proteomic analysis (protein identification with Mascot and/or Sequest Softwares)
Perform quantitative proteomic analysis (label-free and labeled analyses)
Analyze/interpret the data to find up/down regulated proteins

Block Courses in 2nd Quarter of the Semester
From 13.10.2022 - 4.11.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0345-00L</td>
<td>Mechanisms of Bacterial Pathogenesis</td>
<td>W</td>
<td>6</td>
<td>7</td>
<td>W.-D. Hardt, B. Nguyen</td>
</tr>
<tr>
<td></td>
<td>The enrolment is done by the D-BIOL study administration.</td>
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<tr>
<td>Abstract</td>
<td>Research laboratory class in small groups. Research projects on current topics in cellular microbiology and bacterial pathogenesis are assigned to each student.</td>
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<tr>
<td>Objective</td>
<td>Introduction to a current topic in cellular microbiology and/or molecular genetics of a bacterial pathogen. Experimental work in the research lab and introduction to the current lab techniques. This includes contributions to the analysis of animal experiment. You will work with the current research literature in bacterial pathogenesis and write a research protocol. Requirement for obtaining the credit points: oral presentation of the research project, a short written exam and evaluation of the research protocol.</td>
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<tr>
<td>Content</td>
<td>Research projects on the model pathogen Salmonella.</td>
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<tr>
<td>Prerequisites</td>
<td>None.</td>
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<tr>
<td>Literature</td>
<td>Literature will be selected with reference to the assigned research project.</td>
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</table>

| 551-0421-00L   | Biology and Ecology of Fungi in Forests    | W    | 6    | 7     | S. Prospero, I. L. Brunner, M. Peter Baltensweiler |
|                | The enrolment is done by the D-BIOL study administration. |
| Abstract       | Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures. |
| Objective      | Knowledge of the fungi of forest and its ecological significance. Knowing of current methodological research approaches. Self-reliant and deepened activities of selected topics of fungi from forests. |
| Content        | Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures. |
| Prerequisites  | Literature to the Kurs werden abgegeben. |

| 551-0351-00L   | Membrane Biology                           | W    | 6    | 7     | V. Korkhov, U. Kutay           |
|                | The enrolment is done by the D-BIOL study administration. |
| Abstract       | The course will introduce the students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course. |
| Objective      | The aim of the course is to expose the students to a wide range of modern research areas encompassed by the field of membrane biology. |
| Content        | Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field. |
| Lecture notes  | No script                                  |
| Literature     | The recommended literature, including reviews and primary research articles, will be provided during the course |
| Prerequisites  | The course will be taught in English. All general lectures will be held at ETH Hoenggerberg. Students will be divided into small groups to carry out experiments at ETH or at the Paul Scherrer Institute. Travel to the Paul Scherrer Institute will be by public transportation. |

| 551-1201-00L   | Computational Methods in Genome and Sequence Analysis                           | W    | 6    | 7     | A. Wutz                        |
|                | Number of participants limited to 7. The enrolment is done by the D-BIOL study administration. |
| Abstract       | This course aims to provide students with a comprehensive overview of computational methods for sequence analysis and assist with developing skills for application of computational approaches by experimental scientists in the life sciences. |
| Objective      | Methods for analyzing animal genomes are increasingly becoming important for applications in human health and biotechnology suggesting that the experience will be useful to develop relevant expertise for a broad range of functions. Students will have the opportunity to advance their knowledge in programming by focusing on algorithms for genome and gene sequence analysis. A major goal of the course will be to lead the student to an independent and empowered attitude towards computational problems. For reaching this goal the students will work on an implementation of a solution for a set real-world problem in genome and sequence analysis under guided supervision. |

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 267 of 2345
The course will consist of a series of lectures, assignments for implementing elementary tasks in Python, project development and discussion workshops, and a half week of practical work implementing a Python script as a solution to a real world problem associated with sequence analysis. At the end of the course students will explain their solutions and demonstrate the functionality of their implementations, which will then be discussed and commented on by the group. It is expected that students will be able to apply the knowledge to improve on concrete problems.

Prerequisites / notice
- It is recommended to bring your own computer with a Python installation to the course
- simple computers can be provided
- Programming basics with Python

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<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-1143-00L</td>
<td>Analysis of Human T and B Cell Responses to Infectious Agents</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>F. Sallusto, R. Geiger, D. Latorre</td>
</tr>
<tr>
<td>Number of participants limited to 15. The enrolment is done by the D-BIOL study administration.</td>
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</table>

Abstract
Students actively participate in ongoing research projects on the analysis of human T and B cell response to pathogens and vaccines. They will be tutored in small groups by doctoral students and postdocs. In a lecture series, the theoretical background for the projects will be provided and the students will have the opportunity to present their projects and discuss recent publications.

Objective
To learn current methodologies in human immunology through experimental work in the lab. To learn current concepts through lectures and discussion of original papers. Requirement for obtaining the credit points: oral presentation of the research project in a ppt format.

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<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0359-00L</td>
<td>Plant Biochemistry</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>S. C. Zeeman, B. Pfister</td>
</tr>
<tr>
<td>Number of participants limited to 11. The enrolment is done by the D-BIOL study administration.</td>
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Abstract
In this block course, students actively participate in ongoing research projects on plant metabolism and are tutored by doctoral students and postdocs. The theoretical background of the projects is provided in a lecture series. Finally, students discuss their projects and results during an interactive poster session.

Objective
Through supervision in small groups (either individually or in groups of two) students learn to conduct experiments in molecular plant biology, interpret the results, record them and communicate to peers. Students also gain an insight into the larger context of their projects and how they are planned in the longer term.

Content
Participation in a project from the following list is possible: 1) Photosynthesis: How is photosynthesis regulated and how is photosynthesis degraded? 2) Biology of chloroplasts: How do chloroplasts develop and how is their function coordinated with that of the whole cell? 3) Starch biosynthesis and degradation: How are starch granules produced from monosaccharides and how are they broken down again to release energy?

Lecture notes
No script

Literature
Descriptions of the possible projects including individual reading suggestions will be handed out beforehand.

Block Courses in 3rd Quarter of the Semester
From 8.11.2022 - 30.11.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0355-00L</td>
<td>Phytopathology</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>M. Maurhofer Bringolf, B. McDonald</td>
</tr>
<tr>
<td>Number of participants limited to 12. The enrolment is done by the D-BIOL study administration.</td>
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Abstract
Fundamentals (theoretical and practical) in phytopathology, eg. interaction between plants and plant-pathogenic microorganisms, morphology and lifecycles of plant-pathogenic fungi, evolution of plant-pathogenic fungi, biological control of plant diseases

Objective
Insight into ongoing research projects

Content
Experiments within ongoing phytopathological research projects
Macro- and microscopic diagnostic of plant diseases

Theoretical courses:
Fundamentals of phytopathology, eg. interaction between plants and plant-pathogenic microorganisms, morphology and lifecycles of plant-pathogenic fungi, evolution of plant-pathogenic fungi, biological control of plant diseases

Lecture notes
Teaching language is English and German.

Prerequisites / notice
The course will be taught partly in English, partly in German.

Taught competencies
Subject-specific Competencies: Concepts and Theories, assessed
Method-specific Competencies: Techniques and Technologies, assessed
Social Competencies: Analytical Competencies, not assessed
- computing: Communication, not assessed
- personal: Cooperation and Teamwork, not assessed
- critical thinking: Critical Thinking, not assessed

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0739-01L</td>
<td>Biological Chemistry B: New Enzymes from Directed Evolution Experiments</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>P. A. Kast, K. Würth-Roderer</td>
</tr>
<tr>
<td>Number of participants limited to 14.</td>
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</tbody>
</table>
Analytical Competencies

Objective
All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

Content
The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

Lecture notes
A script will be distributed to the participants on the first day of the course.

Literature
General literature to "Directed Evolution" and chorismate mutases, e.g.:


This laboratory course will involve experiments that require a tight schedule and, particularly in the second half, very long (!) working days. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Prerequisites / notice
Further literature will be indicated in the distributed script.

551-0336-00L Methods in Cellular Biochemistry

Abstract
Students will learn about biochemical approaches to analyze cellular functions. The course consists of practical projects in small groups, lectures and literature discussions. The course concludes with the presentation of results at a poster session.

Objective
Students will learn to design, carry out and assess experiments using current biochemical and cell biological strategies to analyze cellular functions in model systems. In particular they will learn novel imaging techniques along with biochemical approaches to understand fundamental cellular pathways. Furthermore, they will learn to assess strengths and limitations of the different approaches and be able to discuss their validity for the analysis of cellular functions.

Literature
Documentation and recommended literature (review articles and selected primary literature) will be provided during the course.

551-1515-00L Insulin Signaling

Abstract
Introduction to the physiological and biochemical action of insulin signaling and its role in the fasted/feeding response and in obesity and diabetes.

Objective
The students will obtain an overview about the current topics of research in insulin signaling and how it impacts on growth, metabolism and cell differentiation. They will learn to design experiments and use techniques necessary to analyze different aspects of insulin signaling, including physiological actions in whole animals as well as in tissue culture. Through lectures and literature seminars, they will learn about the open questions of insulin signaling research and discuss approaches to address these questions experimentally.

In practical lab projects the students will perform physiological in vivo studies as well as biochemical experiments. Finally, they will learn how to present and discuss their data. Student assessment is a graded semester performance based on individual performance in the laboratory, a written exam and the lab data presentation.

575-4020-00L Experimental Food Microbiology for Biologists

Abstract
The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The class with its very dense program consists of the practical course itself and an integrated series of seminar/lecture sessions.

Objective
All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

Content
The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

Lecture notes
A script will be distributed to the participants on the first day of the course.

Literature
General literature to "Directed Evolution" and chorismate mutases, e.g.:
Abstract
Teaching of basic experimental knowledge for detection and identification of microorganisms in food. Practical experiments were accompanied by theoretical introductions. Students become acquainted with classical and state-of-the-art molecular techniques for the rapid detection of food borne pathogens and experiments in dependence on current research topics of the Laboratory of Food Microbiology.

Objective
Introduction of methods and techniques of food microbiology.

Content
Learning basic experimental knowledge for detection and identification of foodborne pathogens by applying state-of-the-art techniques as well as modern molecular techniques for the rapid identification of relevant foodborne pathogens.

Lecture notes
Handouts were provided at the start of the course.

Literature
- Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- Süßmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

Prerequisites / notice

551-1517-00L

Protein Change in Adaptive Evolution

Number of participants limited to 5. The enrolment is done by the D-BIOL study administration.

Abstract
Proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.

Objective
To learn techniques in protein structure prediction, functional prediction and evolutionary analyses (bioinformatic), as well as protein purification from e. coli, insect cell, and/or cell-free systems, and analysis of e.g. interactions with DNA, thermostability, etc…

Content
Guided research projects to study the biochemical consequences of adaptive evolution in a variety of proteins. Mostly the focus is on proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.

Lecture notes
Will be provided, as appropriate, during the course.

Literature
Will be provided during course.

551-1119-00L

Microbial Community Genomics

Number of participants limited to 10. Prerequisite: Basic knowledge in [R] (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer. The enrolment is done by the D-BIOL study administration.

Abstract
Introduction to current research methods in the analysis of microbial communities using Next Generation Sequencing approaches - metagenomics. Practical experience of work in a computational laboratory and an introduction to scientific programming.

Objective
Gain skills in data analysis and presentation for oral and written reports. Lectures introducing state-of-the-art in respective research areas and community microbiology, which is the target of ongoing research. Start to assess current literature.

Prerequisites / notice
Basic knowledge in [R] (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer.

551-1147-00L

Bioactive Natural Products from Bacteria

Number of participants limited to 8. The enrolment is done by the D-BIOL study administration.

Abstract
Lab course. In small groups projects of relevance to current research questions in the field of bacterial natural product biosynthesis are addressed.

Objective
Introduction to relevant subjects of the secondary metabolism of bacteria. Training in practical work in a research laboratory. Scientific writing in form of a research report.

Content
Research project on bacteria that produce bioactive natural products (e.g., Streptomycetes, Cyanobacteria, uncultivated bacteria). The techniques used will depend on the project, e.g. PCR, cloning, natural product analysis, precursor feeding studies, enzyme expression and analysis.

Lecture notes
Will be provided for each of the projects at the beginning of the course.

Literature

Block Courses in 4th Quarter of the Semester

From 1.12.2022 - 23.12.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0361-00L</td>
<td>Biology of Bryophytes and Ferns</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>R. Holdereregger, A. L. Bergamini</td>
</tr>
</tbody>
</table>
| Abstract        | Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes; field trip.  
| Objective       | Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes.  
| Content         | Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes.  
| Lecture notes   | Handouts will be distributed.              |
| Prerequisites / notice | Students have to present a poster on a special topic.  
| Grade according to poster presentation and contributions during the course. |

551-1309-00L

RNA-Biology

Number of participants limited to 17. The enrolment is done by the D-BIOL study administration.

Abstract
RNA-Biology

Objective

Content

Literature

Prerequisites / notice

Data: 18.08.2022 12:39

Autumn Semester 2022

Page 270 of 2345
Introduction to the diversity of current RNA-research at all levels from structural biology to systems biology using mainly model systems like S. cerevisiae (yeast), mammalian cells.

The students will obtain an overview about the diversity of current RNA-research. They will learn to design experiments and use techniques necessary to analyze different aspects of RNA biology. Through lectures and literature seminars, they will learn about the burning questions of RNA research and discuss approaches to address these questions experimentally. In practical lab projects the students will work in one of the participating laboratories. Finally, they will learn how to present and discuss their data in an appropriate manner. Student assessment is a graded semester performance based on individual performance in the laboratory, the written exam and the poster presentation.

The course will be taught in English.

Number of participants limited to 20.

The enrolment is done by the D-BIOL study administration.

This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer.

To learn the cellular and molecular principles underlying tissue repair processes, in particular in the skin and in the liver, and the parallels and differences to cancer. To learn modern technologies in Molecular and Cellular Biology as well as Histology and to use these technologies to study questions related to mechanisms underlying tissue repair and cancer.

This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer. Experimental approaches include biochemical studies, molecular and cellular studies using cultured cell lines and primary cells, as well as analysis of murine and human tissues.

The course combines practical work with lectures, discussions, project preparations and presentations.

siehe Lernmaterialien

Number of participants limited to 15.

The enrolment is done by the D-BIOL study administration.

The goal is to acquire the techniques to image bacteria by electron cryotomography, resolving their structure in a native state, in 3D, and to...

This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer.

Number of participants limited to 5.

The enrolment is done by the D-BIOL study administration.

Motor proteins convert chemical energy into mechanical motion. In this block course, we study dynein motor proteins in cilia. Dynein causes conformational change upon ATP hydrolysis and finally generate ciliary bending motion. Participants will analyze cryo-EM data of cilia and visualize in 3D structure of dynein to learn how motor proteins function in the cell.

The goal of this course is to be familiar with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies on motor proteins. The main focus is 3D image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.

Number of participants limited to 6.

The enrolment is done by the D-BIOL study administration.

Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. Their function is essential for intracellular transport, muscle contraction and other cellular motility as well as cell division. Motor proteins have been major targets of biophysical studies. There exist questions from atomic to tissue levels – how ATP hydrolysis causes conformational change of motor proteins; how their motion is regulated by calcium, phosphorylation and other factors; how motions of multiple motor proteins are coordinated to generate cellular motility. Structural biology has been playing central roles to answer these questions. X-ray crystallography and single particle cryo-EM address structural analysis at atomic resolution and try to reveal molecular mechanism of conformational change. Cryo-electron tomography analyze localization and 3D structure of motor proteins in the cell to explain how motions of molecular motors happen in the context of cellular environments and are integrated into cellular motion. In this course, we study dyneins in cilia. Cilia are force-generating organelles, made by nine microtubules and thousands of dyneins. Dynein hydrolyzes ATP and undergoes conformational change, generating linear motion with respect to the microtubule. As a whole system, cilia integrate motions of these dyneins and orchestrate beating motion. To explain ciliary motion at molecular level, we need to know dynein conformational change in the cellular context. Cryo-electron tomography is recently developed technique to study molecular structures in vivo and therefore a suitable method to study dynein in cilia. Recently spatial resolution of these cryo-EM techniques was dramatically improved, driven by development of new types of detectors and electron optics. The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dyneins, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH. Scripts will be distributed during the course.

An overview is given in the following review articles. Further literature will be indicated during the course.


Students will learn the skills to cultivate bacteria, plunge-freeze samples for cryotomography, collect data using an electron cryomicroscope, process raw data, analyze tomograms, perform subtomogram averaging, model structures of interest, and generate movies for visualization.

https://www.mol.biol.ethz.ch/groups/pilhofer_group/

Number of participants limited to 6.

The enrolment is done by the D-BIOL study administration.

Short peptide amyloids are models for their more complex protein counterparts in the study of disease-related and functional aggregation as well as being interesting in their own right as molecules that may have played a role in the origin of life. This block course will allow the students to study novel peptides in order to characterize their aggregation landscape and also to assess the ability o
Objective: During the block course, each student will learn how to handle aggregation-prone peptides, characterize their aggregation state and structure as well as assay their ability to template their own chemical synthesis.

Content: The course is divided between lectures practical work in the lab. The lectures will introduce the general topic of amyloids and in particular their potential role in the origin of molecular complexity, as well as cover the theory and the practice behind the tools that are used to characterize peptide amyloids. The practical work in the lab will allow the students to gain hands-on experience working on a novel peptide that has yet to be characterized. Since the course consists of genuine research we also hope that new discoveries will be made that will provide insights into the role that amyloids may have played in the origin of life.

Lecture notes: A script will be distributed to the participants on the first day of the course.


Further literature will be indicated in the distributed script.

### Block Courses in the 1st Half of the Semester

**Autumn Semester 2022**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-2437-01L</td>
<td>The course can only be booked via the Biology Office of Student Affairs.</td>
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<tr>
<td>701-2437-01L</td>
<td>The course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, ground water and lakes. This course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) as well as excursions.</td>
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<tr>
<td>701-2437-01L</td>
<td>During this course you will get an overview of the world's typical continental aquatic ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat, and how the interactions (e.g. food web) between organisms work. During the experimental part of this course you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work) and present the collected knowledge. After this course you will know the most important aquatic species groups (macroinvertebrates, microinvertebrates and freshwater algae) in Switzerland and the most important identification traits.</td>
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<tr>
<td>701-2437-01L</td>
<td>The course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) and field excursions. Exercise: The lecture part covers ecology and evolution of aquatic organisms in lentic and lotic waters. Topics include: Adaptations, distribution patterns, biotic interactions, and conceptual paradigms in freshwater ecosystems; important aspects regarding ecosystem metabolism and habitat properties of freshwaters; applied case studies and experiments testing ecological and evolutionary processes in freshwaters. Practical part: The practical part includes an excursion to Greifensee and a 3-day-excursion to the river Glatt in Niederuzwil, where you independently perform small research projects. Additionally, you will perform in small groups an independent experiment in a research group at Eawag. The taxonomic part will cover macroinvertebrates (e.g. Crustacean, aquatic insects), microinvertebrates and algae. The goal is to get to know the most common aquatic taxa in Switzerland, to identify them with commonly used identification literature, and to get an idea how these organisms are used in research and practice. (language: German, translation of the most important things during the course possible)</td>
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<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12 credits</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
<tr>
<td>529-0810-01L</td>
<td>Admittance is limited and depends on the availability of hosting research labs. Interested students are asked to contact Prof. C. Thilgen (<a href="mailto:thilgen@org.chem.ethz.ch">thilgen@org.chem.ethz.ch</a>) before the end of the preceding semester for further details. In case of admittance, the actual enrolment needs to be done via the D-BIOL study administration.</td>
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<tr>
<td>529-0810-01L</td>
<td>An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students. Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.</td>
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<tr>
<td>529-0810-01L</td>
<td>An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.</td>
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<tr>
<td>529-0810-01L</td>
<td>No course notes.</td>
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<tr>
<td>529-0810-01L</td>
<td>No set textbooks. Literature will be indicated or provided by the supervising TAs. Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.</td>
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</tbody>
</table>
Taught competencies

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

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Self-presentation and Social Influence not assessed

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

Block Courses during the Semester Break

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1709-00L</td>
<td>Genomic and Genetic Methods in Cell and Developmental Biology</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>A. Wutz, M. Kopf, T. Schroeder</td>
</tr>
</tbody>
</table>

Abstract
This course aims to provide students with a comprehensive overview of mammalian developmental biology and stem cell systems both on the theoretical as well as the experimental level. Centering the course on genetic and genomic methods engages the students in contemporary research and prepares for future studies in the course of semester and master projects.

Objective
- Understanding mammalian development
- Introduction to stem cells systems
- Working with cultured cells
- Translational aspects of mammalian cell biology
The course will consist of a series of lectures, assay assignments, project development and discussion workshops, and 2 and a half weeks of lab work with different mammalian cell systems embedded in real life research projects. At the end of the course students will take an exam consisting of questions on the topic of the lectures and workshops. It is expected that students will be able to apply the knowledge to concrete problems.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BIOL

Language Courses

see Science in Perspective: Language Courses ETH/UZH

<table>
<thead>
<tr>
<th>Biology Bachelor - Key for Type</th>
<th>Key for Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Suitable for doctorate</td>
<td>V lecture</td>
</tr>
<tr>
<td>O Compulsory</td>
<td>G lecture with exercise</td>
</tr>
<tr>
<td>W+ Eligible for credits and recommended</td>
<td>U exercise</td>
</tr>
<tr>
<td>W Eligible for credits</td>
<td>S seminar</td>
</tr>
<tr>
<td>E- Recommended, not eligible for credits</td>
<td>K colloquium</td>
</tr>
<tr>
<td>Z Courses outside the curriculum</td>
<td>P practical/laboratory course</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Biology Teaching Diploma

Detailed information on the programme at: www.didaktischeausbildung.ethz.ch

Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td>Abstract</td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<tr>
<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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</tbody>
</table>

| 851-0242-07L | Human Intelligence | W | 1 | 1S | E. Stern |
| Number of participants limited to 30. |              |    |   |     |          |
| This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)". |          |    |   |     |          |
| Abstract | The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed. |          |    |   |          |
| Objective | - Understanding of research methods used in the empirical human sciences |          |    |   |          |
|            | - Getting to know intelligence tests |          |    |   |          |
|            | - Understanding findings relevant for education |          |    |   |          |

| 851-0242-08L | Research Methods in Educational Science | W | 1 | 2S | C. M. Thurn, T. Braas, P. Edelsbrunner |
| Number of participants limited to 30. |              |    |   |     |                                      |
| This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)". |          |    |   |     |                                      |
| Abstract | Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work. |          |    |   |                                      |
| Objective | - Understand research methods used in the empirical educational sciences |          |    |   |                                      |
|            | - Understand and critically examine information from scientific journals and media |          |    |   |                                      |
|            | - Understand pedagogically relevant findings from the empirical educational sciences |          |    |   |                                      |

| 851-0242-11L | Gender Issues In Education and STEM | W | 2 | 2S | M. Berkowitz Biran, T. Braas, C. M. Thurn |
| Number of participants limited to 30. |              |    |   |     |                                        |
| Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |          |    |   |     |                                        |
| Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it. |          |    |   |     |                                        |
| Abstract | In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed. |          |    |   |                                        |
| Objective | - To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues |          |    |   |                                        |
|            | - To develop a critical view on existing research and perspectives. |          |    |   |                                        |
|            | - To integrate this knowledge with teacher's work. |          |    |   |                                        |
| Content | Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them. |          |    |   |                                        |
| The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar. |          |    |   |                                        |
| Prerequisites / notice | Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1). |          |    |   |                                        |

| 851-0229-00L | Using Outdoor Education | W | 1 | 1S | R. Schumacher, P. Faller |
| Number of participants limited to 40. |              |    |   |     |                          |
| Enrolment only possible with matriculation in Teaching Diploma Biology and Geography. |          |    |   |     |                          |
| Abstract | In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf. |          |    |   |                          |
Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt. The objectives for the students are:

- Students can discuss and put into practice in their teaching work the conditions and objectives set out in the regulations governing the Mentored Work Subject Didactics Biology

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures. Under supervision, they compile tuition materials enabling effective learning and/or analyse and reflect on certain topics from a subject-based and pedagogical perspective.

Objective: The objectives for the students are:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics, pedagogical, and potentially social perspective.

- to prove that they can independently compile a tuition sequence and develop it to deployment.

Subject Didactics in Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0961-00L</td>
<td>Mentored Work Subject Didactics Biology A</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>P. Faller, H. Stocker</td>
</tr>
<tr>
<td></td>
<td>The Subject Didactics as well as possible branch-specific requirements must be fulfilled prior to commencing the mentored paper.</td>
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<tr>
<td>Abstract</td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures. Under supervision, they compile tuition materials enabling effective learning and/or analyse and reflect on certain topics from a subject-based and pedagogical perspective.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The objectives for the students are:</td>
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<tr>
<td></td>
<td>- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics, pedagogical, and potentially social perspective.</td>
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<tr>
<td></td>
<td>- to prove that they can independently compile a tuition sequence and develop it to deployment.</td>
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Subject Didactics in Biology I

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0971-00L</td>
<td>Subject Didactics Biology I</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>P. Faller</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in Introductory Internship Biology</td>
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<tr>
<td>Abstract</td>
<td>- Basic conditions for tuition (MAR - recognition of Matura certificates - curricula, standards), selection of topics and reduction of the complexity of topics.</td>
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<td></td>
<td>- Application of teaching methods and techniques from educational science in biology classes.</td>
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<td></td>
<td>- Planning and preparation of lessons.</td>
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<tr>
<td>Objective</td>
<td>- Students can discuss and put into practice in their teaching work the conditions and objectives set out in the regulations governing the school-leaving examination (Matura), the framework curriculum and the conditions and objectives specified by their school.</td>
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<td></td>
<td>- They are in a position to select learning objectives and formulate these on the basis of the target level model. They can plan and prepare lessons and can also develop appropriate learning assignments.</td>
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<td></td>
<td>- Students can reconstruct specialist contents in didactic terms and develop teaching modules suitable for the different levels from these on the basis of the subject structure and learner requirements.</td>
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<td></td>
<td>- They can reduce the complexity of subject-based specialist contents and present them in such a way that they are comprehensible and meaningful for learners.</td>
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<td></td>
<td>- They can select appropriate media for their work (e.g. school books) and use these. They can employ appropriate experiments.</td>
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<td></td>
<td>- The students can use different forms of examination for monitoring performance.</td>
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<td></td>
<td>- Students are in a position to implement and discuss the concepts of biology teaching and learning on the basis of specific topics covered in school biology.</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 276 of 2345
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-

**Professional Training**

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

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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</tr>
</thead>
<tbody>
<tr>
<td>551-0968-00L</td>
<td>Introductory Internship Biology</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>P. Faller</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in Biology Didactics I - course 551-0871-00L - is compulsory.</td>
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<tr>
<td>Abstract</td>
<td>During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.</td>
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<tr>
<td>Objective</td>
<td>Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training.</td>
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<tr>
<td>Literature</td>
<td>Wird von der Praktikumslehrperson bestimmt.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>551-0969-00L - belegen.</td>
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<tbody>
<tr>
<td>551-0966-00L</td>
<td>Teaching Internship Biology</td>
<td>O</td>
<td>8</td>
<td>17P</td>
<td>P. Faller</td>
</tr>
<tr>
<td>Abstract</td>
<td>The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.</td>
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<tr>
<td>Objective</td>
<td>- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.</td>
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<td></td>
<td>- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.</td>
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<td></td>
<td>- They acquire the skills of the teaching trade.</td>
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<td></td>
<td>- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.</td>
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<td>- They learn to assess pupils’ work.</td>
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<td></td>
<td>- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.</td>
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<tr>
<td>Literature</td>
<td>Wird von der Praktikumslehrperson bestimmt.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.</td>
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<tr>
<td>551-0969-01L</td>
<td>Examination Lesson I Biology</td>
<td>O</td>
<td>1</td>
<td>2P</td>
<td>P. Faller</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in “Examination Lesson II Biology” (551-0969-02L) is compulsory.</td>
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<tr>
<td>Abstract</td>
<td>In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.</td>
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<td>Objective</td>
<td>On the basis of a specified topic, the candidate shows that they are in a position</td>
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<td>- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle</td>
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<td>- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.</td>
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<tr>
<td>Lecture notes</td>
<td>Dokument: Schriftliche Vorbereitung für Prüfungslektionen.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Nach Abschluss der übrigen Ausbildung.</td>
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</tbody>
</table>
Students conduct a series of "classical" biological school experiments and therefore gain practice and experience in this area. This includes finding, testing and further developing suitable protocols for different subject areas of school biology. Working out how to didactically embed the experiments in lessons. Students can perform, off the cuff, 12 school experiments (which they have tested themselves), from the different subject areas, and conduct these correctly in technical terms. They can incorporate these experiments in their tuition in a didactically meaningful manner.

Comments:
By contrast to the Subject Specialisation 1 and 2 course units, these are "basic tests" and do not involve the implementation of current research topics. The students' compilations are available in a data archive.

Content
2. Die Studierenden führen alle ausgearbeiteten Experimente selber durch.

Lecture notes
Hand out of course material.

Prerequisites / notice
Der Teil biologische Experimente findet im Rahmen von 7 Halbtagen statt.


- to prepare tuition units involving complex learning matter at a high specialist level which are suitably tailored to the recipients, and to
- analyse controversial topics and to give factual explanations for these.
- to retrieve in-depth knowledge of biology with a special focus on evolution and to impart this to others.

Abstract
Standard aspects of biology with a focus on evolution are covered from the angle of imparting these to pupils, their historical development, and their significance for the subject, the individual and society.

Objective
After successful completion of the module, students should be able
- to retrieve in-depth knowledge of biology with a special focus on evolution and to impart this to others.
- to analyse controversial topics and to give factual explanations for these.
- to conduct more in-depth work on a research topic and to compile a tuition unit based on this topic
- to prepare tuition units involving complex learning matter at a high specialist level which are suitably tailored to the recipients, and to teach these in a manner conducive to learning.

Content
Selected biological topics, with a special focus on evolution, are dealt with considering the special needs of persons involved in teaching.

Lecture notes
Teaching materials are available online on Moodle.

Literature
Literature and references are posted online on Moodle.

Prerequisites / notice
The Specialized Biology Course with an Educational Focus consists of two modules (6 CP each). In the fall semester, the focus is on evolution. The module of the spring semester deals with biological concepts. Students attending both modules can start with either module.

Performance is assessed during the course of the entire module. Active participation in the course is required. The thesis (including oral presentation) has to be completed.

The Specialized Biology Course with an Educational Focus (6+6 CP) can be acknowledged, in agreement with the advisor of the respective elective major, as one of the two obligatory research projects (each 15 CP). In such a case, additional 3 CP must be obtained in another course.

In case of overbooking of the course, students enrolled in the Teaching Diploma in Biology will have priority.

Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

Number Title Type ECTS Hours Lecturers
see Compulsory Elective Courses Teaching Diploma

Research Ethics

Number of participants limited to 40

Particularly suitable for students of D-BIOL, D-CHAB, D-HEST

Abstract
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective
Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people's arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 278 of 2345
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can assess:

I. Introduction to Moral Reasoning

A. What ethics is about
B. What is research misconduct?
C. Questionable/Detrimental Research Practice (QRP/DRP)
D. What is the incidence of misconduct?
E. What are the factors that lead to misconduct?
F. Responding to research wrongdoing
G. The process of dealing with misconduct
H. Approaches to misconduct prevention and for promoting integrity in research

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
   a. What is research integrity and why is it important?
   b. What is research misconduct?
   c. Questionable/Detrimental Research Practice (QRP/DRP)
   d. What is the incidence of misconduct?
   e. What are the factors that lead to misconduct?
   f. Responding to research wrongdoing
   g. The process of dealing with misconduct
   h. Approaches to misconduct prevention and for promoting integrity in research

III. Research Ethics – External responsibilities

1. Research involving human subjects
   a. History of research with human subjects
   b. Basic ethical principles – The Belmont Report
   c. Requirements to make clinical research ethical
   d. Social value and scientific validity
   e. Selection of study participants – the concept of vulnerability
   f. Favourable risk-benefit ratio

2. Social responsibility
   a. Social responsibility of the individual scientist
   b. Social responsibility of the scientific community as a whole

3. Duplex research
   a. Introduction to Duplex research
   b. Case study – Censuring science?
   c. Transmission studies for avian flu (H5N1)
   d. Synthetic biology

Lecturer notes

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice

What are the requirements?

First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):

1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time)!
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...)

Taught competencies

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: assessed

- **Method-specific Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: assessed

**Course Title:** Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement

**Objective:**

Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

**Content:**

The seminar covers the following topics:

1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.
To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and
assessed

Literature will be made available to the participants.

The following open access article builds a core element of the course:
10.14512/gaia.26.1.10
available at (open access): http://www.ingentaconnect.com/content/entou/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

Participants in the course require participants to be working on their own research project.

Prerequisites /
notice

Participation in the course requires participants to be working on their own research project.

Taught
competencies

Subject-specific Competencies
Concepts and Theories
Problem-solving

Social Competencies
Cooperation and Teamwork
Sensitivity to Diversity

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection

Not assessed

Environmental Governance

Number of participants is limited to 30.

Priority is given to the target groups until 19.09.2022,

Target groups:
Environmental Sciences MSc
Agricultural Sciences MSc

Waiting list will be deleted on 23.09.2022

Abstract

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

Objective

To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and

Content

To analyze the evolution as well as the key elements of environmental governance.

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

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

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

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

Lecture notes

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

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

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

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

Taught
competencies

Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Decision-making
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Self-presentation and Social Influence
Sensitivity to Diversity

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

Sustainability Assessment

Does not take place this semester.

Number of participants is limited to 35.

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

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

Objective

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

Content

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

Lecture notes

Handouts are provided

Literature

Selected scientific articles and book-chapters

Prerequisites / notice

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

Taught competencies

Subject-specific Competencies: Concepts and Theories

Social Competencies: Communication

Personal Competencies: Creative Thinking, Critical Thinking

ECTS

not assessed

4V

T. Bernauer

At the end of the course, students:

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

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

Abstract

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

Objective

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

Content

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

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

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

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

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Lecture notes

Reading materials and slides will be available via Moodle.

Literature

Reading materials and slides will be available via Moodle.

Prerequisites / notice

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

► Course Units for Additional Admission Requirements

The courses below are only available for students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

Basic knowledge of the anatomy and physiology of tissues, of the embryonal and postnatal development, the sensory organs, the neuromuscular system, the cardiovascular system and the respiratory system.

Objective

Basic knowledge of human anatomy and physiology and basics of clinical pathophysiology.
The lecture series provides a short overview of human anatomy and physiology

Anatomy and Physiology I (fall term):
- Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system
- Anatomy and Physiology II (spring term):
  - digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.

Prerequisites / notice
- Requirements: 1st year, scientific part.
- Part of the course is read and checked in English.

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Microbiology</td>
<td>752-4001-00L</td>
<td>E-</td>
<td>2 credits</td>
<td>2V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M. Ackermann, M. Schuppler, J. Vorholt-Zambelli</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Objective</td>
<td>Teaching of basic knowledge in microbiology.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Content</td>
<td>Der Schwerpunkt liegt auf den Themen: Bakterielle Zellbiologie, Molekulare Genetik, Wachstumsphysiologie, Biochemische Diversität, Phylogenie und Taxonomie, Prokaryotische Vielfalt, Interaktion zwischen Menschen und Mikroorganismen sowie Biotechnologie.</td>
<td></td>
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<tr>
<td></td>
<td>Lecture notes</td>
<td>Wird von den jeweiligen Dozenten ausgegeben.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td>Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants and Fungi</td>
<td>551-0127-01L</td>
<td>E-</td>
<td>4 credits</td>
<td>3G</td>
</tr>
<tr>
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<td></td>
<td>S. C. Zeeman, M. Künzler, O. Y. Martin</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>The lecture conveys the fundamental concepts underlying multicellularity with an emphasis on the molecular basis of multicellular biological systems and their functional integration into coherent wholes. The structural and functional specialization in multicellular organisms will be discussed by highlighting common and specific functions in fungi and plants.</td>
<td></td>
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<tr>
<td></td>
<td>Objective</td>
<td>1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity.</td>
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<td></td>
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<td>2. Students can explain how the internal and external structures of fungi and plants function to support survival, growth, behavior, and reproduction.</td>
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<td>3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development).</td>
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<td>4. Students can describe how a single cell develops from one cell into many, each with different specialized functions.</td>
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<tr>
<td></td>
<td>Content</td>
<td>The lecture introduces the structural and functional specialization in fungi and plants. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi and plants have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.</td>
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<tr>
<td></td>
<td></td>
<td>Campbell “Biology”, 11th Edition</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
<td>Some lecture are held in English.</td>
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</tbody>
</table>
Evolutionary Genetics

The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics; neutral theory of molecular evolution and basics of coalescent theory. 

Genetic adaptation and evolution - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem.

Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

Research Seminar: Ecological Genetics

In this research seminar we will critically discuss recent publications on current topics in Ecological Genetics. The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

Insect Ecology

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

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

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Applied Analysis of Variance and Experimental Design

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.
This course provides the ecological systems' knowledge needed to question applied sustainability solutions. We will critically assess the options) as an alternative to engineered solutions (e.g. large reservoirs) in flood and drought management; (2) Fire dynamics, the water cycle and biodiversity -- The surprising dynamics of species life cycles and populations in arid landscapes; (3) Rewilding, e.g. re-introducing apex predators (e.g. wolves), or large ungulates (e.g. bisons) in protected areas -- A nature conservation trend with counterintuitive effects; (4) Coupling of aquatic and terrestrial systems: carbon, nitrogen and phosphorus transfers of global importance on landscape scale.

The course is structured around four larger topical areas: (1) Integrated Water Management -- Green infrastructure (land management options) as an alternative to engineered solutions (e.g. large reservoirs) in flood and drought management; (2) Fire dynamics, the water cycle and biodiversity -- The surprising dynamics of species life cycles and populations in arid landscapes; (3) Rewilding, e.g. re-introducing apex predators (e.g. wolves), or large ungulates (e.g. bisons) in protected areas -- A nature conservation trend with counterintuitive effects; (4) Coupling of aquatic and terrestrial systems: carbon, nitrogen and phosphorus transfers of global importance on landscape scale.

Lecture notes

Case descriptions, commented glossary and a list of literature and further resources per case.

Literature


Schulze et al. (2005) Plant Ecology; Springer.

Prerequisites / notice

The course combines elements of a classic lecture, group discussions and problem based learning. It is helpful, but not essential to be familiar with the "seven stages" method (see e.g. course 701-0352-00L "Analysis and Assessment of Environmental Sustainability" by Christian Pohl et al.).

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

The course provides the first part an introduction to the statistical software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects. The students will be able to use the software R for simple data analysis and graphics.
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

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

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

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>An Introduction to R. <a href="http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf">http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf</a></td>
<td>The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should &quot;automatically&quot; make you a student participant of the Moodle course of this lecture, which is at <a href="https://moodle-app2.let.ethz.ch/course/view.php?id=15518">https://moodle-app2.let.ethz.ch/course/view.php?id=15518</a></td>
</tr>
</tbody>
</table>

### Using R for Data Analysis and Graphics (Part II)

**W 1.5 credits 1G**

**M. Mächler**

**Abstract**

The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

**Objective**

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

**Content**

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

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

**Lecture notes**

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

**Prerequisites / notice**

Basic knowledge of R equivalent to "Using R .. (part 1)" (= 401-6215-00L ) is a prerequisite for this course.

**401-6217-00L**

**Plant Pathology I**

**W 2 credits 2G**

**B. McDonald**

**Abstract**

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

**Objective**

Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.

**Lecture notes**

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=15522

**751-4504-00L**
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

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

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

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

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

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

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


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

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

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


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

Week 13 Cultural control methods: fertilizers, crop rotations.

Week 14 Open lecture.

636-0017-00L Computational Biology W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Stadler

Abstract

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

701-1471-00L Ecological Parasitology W 3 credits 1V+1P J. Jokela, C. Vorburger
Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

Practical exercises:
1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

Prerequisites / notice
The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

Evolutionary Medicine for Infectious Diseases

Number of participants limited to 35.

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
Chevreul 2012 Evolutionary Medicine
Hesseling & Koopmans 2014 Emerging Infectious Diseases
Scheffler 2017 Evolutionary Medicine
Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Evolutionary Dynamics

Abstract
Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

Objective
The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Content
Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

Literature

Prerequisites / notice
Prerequisites: Basic mathematics (linear algebra, calculus, probability)

Advanced Ecological Processes

For students of the following study programmes only:
Biology Master
Teaching certificate Biology
Environmental Sciences Master
UZH MNF Biology
UZH MNF Geography /Earth Sciences

Abstract
This course presents theoretical and empirical approaches to understanding the ecological processes structuring populations and communities. Central problems covered include species interactions, spatial structure, resource dynamics, and ecological responses to environmental change. These and other topics will be explored from basic and applied perspectives.
This course focuses on the concepts of classical and modern genetics and genomics.

4G Microbiology (Part I)

Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

- Adaptability and Flexibility
- Conceptual Topics

Each student will understand:

Upon completing the course, students will be able to:

Understand the factors determining the outcome of species interactions in communities, and how this information informs management.

Applying theoretical knowledge on species interactions to predict the potential outcomes of novel species introductions.

Understanding the role of spatial structure in mediating population dynamics and persistence, species interactions, and patterns of species diversity.

Use population and community models to predict the stability of interactions between predators and prey and between different competitors.

Understand the conceptual basis of predictions concerning how ecological communities will respond to global change.

Discuss the types of conceptual advances ecology as a science can realistically achieve, and how these relate to the applications of the discipline.

Lectures supplemented with readings from the primary literature and occasional computer exercises will focus on understanding central processes in community ecology. Topics will include demographic and spatial structure, consumer resource interactions, food webs, competition, mutualism, invasion, the maintenance of species diversity, and species effects on ecosystem processes. Each of these concepts will be discussed in concert with their applications to the conservation and management of species and communities in a changing world.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Negotiation</td>
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<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
<td>Adaptability and Flexibility</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Creative Thinking</td>
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<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
<td>Critical Thinking</td>
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<td>Project Management</td>
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<td>Integrity and Work Ethics</td>
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#### Elective Concept Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voithet</td>
</tr>
<tr>
<td>551-1299-00L</td>
<td>Bioinformatics</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>S. Sunagawa, P. Beltrao, A. Blasimme, A. Kahles, C. von Mering, N. Zamboni</td>
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**Data: 18.08.2022 12:39**

**Autumn Semester 2022**

**Page 288 of 2345**
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, bioinformatics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

Elective Major: Microbiology and Immunology

Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
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</table>

Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
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Abstract
Introduction into structural and functional aspects of the immune system.

Objective
Introduction into structural and functional aspects of the immune system.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed
This course provides a detailed understanding of:
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological textbook knowledge has evolved.

Obtain a detailed understanding of:
- the development, activation, and differentiation of different types of T cells and their effectormechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&noti/yedtiingon=1

Immunology I and II recommended but not compulsory

<table>
<thead>
<tr>
<th>551-0512-00L</th>
<th>Current Topics in Molecular and Cellular Neurobiology</th>
<th>W</th>
<th>2 credits</th>
<th>1S</th>
<th>U. Suter</th>
</tr>
</thead>
</table>

The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

The papers we present are available online, so you can show original figures with a beamer. Finish with a summary of the main points and a discussion of their significance.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

Presentations will be made available after the seminars.

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

<table>
<thead>
<tr>
<th>551-1117-00L</th>
<th>Cutting Edge Topics: Immunoimmunology and Infection Biology</th>
<th>W</th>
<th>2 credits</th>
<th>1S</th>
<th>A. Oxenius, B. Becher, C. Halin Winter, M. Kopf, S. R. Leibundgut, C. Münz, L. Tortoli, M. van den Broek</th>
</tr>
</thead>
</table>

Information for UZH students: Enrolment to the course unit only possible at ETH. No enrolment to module BIO636 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.

The aim of this course is to confront students with current research topics and with scientific presentation. The course offers the opportunity to gain in depth knowledge about diverse topics which are often only briefly touched in the concept courses and to engage in discussion with experts in the field.

The specific topics are variable and depend each semester on the list of invited experts.

Often parts of the presented seminars have already been published by the respective speakers and the respective primary research can be retrieved from scientific journals.
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.
Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-5103-00L Functional Microorganisms in Foods
W 3 credits 2G C. Lacroix, A. Geirnaert, A. Greppi

Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

Lecture notes
Copy of the power point slides from lectures will be provided.

Literature
A list of topics for group projects will be supplied, with key references for each topic.

Prerequisites / notice
This lecture requires strong basics in microbiology.

751-4504-00L Plant Pathology I
W 2 credits 2G B. McDonald

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

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

Lecture Topics and Tentative Schedule

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

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

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

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

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

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


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

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

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


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

Week 13 Cultural control methods: fertilizers, crop rotations.

Week 14 Open lecture.

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

636-0017-00L Computational Biology W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Studler

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GAWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylo Dynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Literature
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective

- Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms
- Students will evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals.

Content

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (~20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature

The focus is on primary literature, but for some parts the following text books provide good background information:

- Stearns & Medzhitov 2016 Evolutionary Medicine
- Schmid Hempel 2011 Evolutionary Parasitology
- M. Loessner

Prerequisites / notice

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-4005-00L</td>
<td>Food Microbiology I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Loessner</td>
</tr>
</tbody>
</table>

Abstract

This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Objective

The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Content

1. History of Food Microbiology
2. Overview of Microorganisms in Foods
3. Microbial Spoilage of Foods
4. Foodborne Disease

Literature

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-2413-00L</td>
<td>Evolutionary Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>T. Städel, A. Widmer, S. Fior, M. C. Fischer, J. Stapley</td>
</tr>
</tbody>
</table>

Abstract

The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Objective

The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossingbreeding, effects on fitness; Fisher's fundamental theorem.

Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

Literature

The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.

Objective
The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.

Content
The course "Molecular Life of Plants" will cover the following topics:
- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
- Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
- Senescence

551-0307-00L Molecular and Structural Biology I: Protein Structure and Function
W 3 credits 2V R. Glockshuber, K. Locher, E. Weber-Ban

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytical methods.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

551-0309-00L Concepts in Modern Genetics
W 6 credits 4V Y. Barral, D. Bopp, A. Hajnal, O. Voinnet

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

551-0319-00L Cellular Biochemistry (Part I)
W 3 credits 2V U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.
Lecturers
Nucleic Acids and Carbohydrates

Mainly based on original literature, a detailed list will be distributed during the lecture.

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

551-1299-00L  Biinformatics

W 6 credits  4G

S. Sunagawa, P. Beltrao, A. Blasimme, A. Kahles, C. von Mering, N. Zamboni

Abstract

Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioinformatics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective

Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice

Course participants have already acquired basic programming skills in Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

529-0731-00L  Nucleic Acids and Carbohydrates

W 6 credits  3G

K. Lang, P. A. Kast, S. J. Sturla, H. Wennemers

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

Abstract

Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content

Scripts and function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes

No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Prerequisites / notice

Mainly based on original literature, a detailed list will be distributed during the lecture.

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Techniques and Technologies

Analytical Competencies

Problem-solving

Social Competencies

Communication

Cooperation and Teamwork

Personal Competencies

Self-awareness and Self-reflection

Self-direction and Self-management

EECTT  Hours  Lecturers

651-0319-00L  Cellular Biochemistry (Part I)

W 3 credits  2V

U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp

Abstract

Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytokoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will learn to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

551-0309-00L  Concepts in Modern Genetics

W 6 credits  4V

Y. Barral, D. Bopp, A. Hajnal, O. Voinnet

Information for UZH students:

Enrollment to this course unit only possible at ETH. No enrollment to module BIOC348 at UZH.

Enrolment to this course unit only possible at ETH. No enrollment to module BIOC348 at UZH.
Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

551-0317-00L  Immunology I

Abstract
Introduction into structural and functional aspects of the immune system.
Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Introduction into structural and functional aspects of the immune system.
Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Communication</th>
<th>Cooperation and Teamwork</th>
<th>Customer Orientation</th>
<th>Leadership and Responsibility</th>
<th>Self-presentation and Social Influence</th>
<th>Sensitivity to Diversity</th>
<th>Negotiation</th>
<th>Adaptability and Flexibility</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
<th>Self-awareness and Self-reflection</th>
<th>Self-direction and Self-management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
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<tr>
<td>Techniques and Technologies</td>
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</table>

551-1299-00L  Bioinformatics

Abstract
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in Python and R.

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0512-00L</td>
<td>Current Topics in Molecular and Cellular Neurobiology</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Suter</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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</tbody>
</table>

Abstract
The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.
Objective
The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

Content
You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

Prerequisites / notice
You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

Lecture notes
Presentations will be made available after the seminars.

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Title</th>
<th>Credits</th>
<th>Type</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0571-00L</td>
<td>From DNA to Diversity (University of Zurich)</td>
<td>W 2 credits 2V</td>
<td>2 credits</td>
<td>A. Hajnal, D. Bopp</td>
</tr>
<tr>
<td>Mind the enrolment deadlines at UZH: <a href="https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html">https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html</a></td>
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<tr>
<td>Abstract</td>
<td>The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analysed model organisms.</td>
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<tr>
<td>Objective</td>
<td>By the end of this module, each student should be able to - recognize the universal principles underlying the development of different animal body plans. - explain how the genes encoding the molecular toolkit have evolved to create animal diversity. - relate changes in gene structure or function to evolutionary changes in animal development.</td>
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<tr>
<td>Key skills:</td>
<td>By the end of this module, each student should be able to - present and discuss a relevant evolutionary topic in an oral presentation - select and integrate key concepts in animal evolution from primary literature - participate in discussions on topics presented by others</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>551-1117-00L</td>
<td>Cutting Edge Topics: Immunology and Infection Biology</td>
<td>W 2 credits</td>
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<tr>
<td>Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO336 at UZH.</td>
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<tr>
<td>Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students-special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/non-degree-courses/special-students-special-students-university-of-zurich.html</a></td>
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<tr>
<td>Abstract</td>
<td>Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.</td>
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<tr>
<td>Objective</td>
<td>Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion. The aim of this course is to confront students with current research topics and with scientific presentation. The course offers the opportunity to gain in depth knowledge about diverse topics which are often only briefly touched in the concept courses and to engage in discussion with experts in the field.</td>
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<tr>
<td>Content</td>
<td>Immunology and infection biology. The specific topics are variable and depend each semester on the list of invited experts.</td>
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<tr>
<td>Lecture notes</td>
<td>Current research data (often not yet published) are presented in this seminar series. There is no script and we are not allowed to record or distribute the contents of the seminars. Thus, the ability of students to extract the most relevant points of each seminar is promoted, which is an important skill for the future attendance of scientific meetings.</td>
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<tr>
<td>Literature</td>
<td>Often parts of the presented seminars have already been published by the respective speakers and the respective primary research can be retrieved from scientific journals.</td>
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</tbody>
</table>
Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.

During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

The course will be taught in English.


taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

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

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

Technical, Methodological, and Subject-Specific Competencies

Analysis of data
Critical thinking
Scientific writing

Abstract

Systems Biology of Metabolism

Number of participants limited to 15.

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Content

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

Lecture notes

Script and original publications will be supplied during the course.

Prerequisites / notice

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

Immunology: From Milestones to Current Topics

Milestones in Immunology: on old concepts and modern experiments

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Lecture notes

Original and review articles will be distributed by the respective lecturer.

Literature

Literaturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

Immunology: From Milestones to Current Topics

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Lecture notes

Original and review articles will be distributed by the respective lecturer.

Literature

Literaturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

Cellular Biochemistry of Health and Disease

Number of participants limited to 20.

During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

Objective

Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry.

Content

Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

Literature

The literature will be provided during the course

The course will be taught in English.

Chemical Biology and Synthetic Biochemistry

Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.

The course will be taught in English.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 299 of 2345
Overview of enzymes, enzyme-catalyzed reactions and metabolic processes.

Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.

A script will not be handed out.

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Overview of enzymes, enzyme-catalyzed reactions and metabolic processes.

Does not take place this semester.

Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Immunology III

This course provides a detailed understanding of
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

- the development, activation, and differentiation of different types of T cells and their effectormechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Immunology I and II recommended but not compulsory
Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content
- Basics of theory of probability
- Boltzmann’s law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes
No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o’clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature

Prerequisites / notice
Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

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

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

376-1305-01L Neural Systems for Sensory, Motor and Higher Brain Functions

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO343 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Abstract
The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

Objective
The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.

Content
The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.
### 376-1305-00L Development of the Nervous System (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: BIO344


**Objective**: On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

**Key skills**: On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

**Content**: The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

**Lecture notes**: Must be downloaded from OLAT: [https://www.olat.uzh.ch/olat/dmz/](https://www.olat.uzh.ch/olat/dmz/) as BIO344

**Literature**: The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

**Prerequisites / notice**: BIO142 Developmental Biology, BIO143 Neurobiology

### Elective Major: Molecular Health Sciences

### Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barrai, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>

**Abstract**: Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**: This course focuses on the concepts of classical and modern genetics and genomics.

**Content**: The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**: Scripts and additional material will be provided during the semester.

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>551-1299-00L</td>
<td>Bioinformatics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>S. Sunagawa, P. Beltrao, A. Blasimme, A. Kahles, C. von Mering, N. Zamboni</td>
</tr>
</tbody>
</table>

**Abstract**: Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

**Objective**: Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

**Prerequisites / notice**: Course participants have already acquired basic programming skills in Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>S. Sunagawa, P. Beltrao, A. Blasimme, A. Kahles, C. von Mering, N. Zamboni</td>
</tr>
</tbody>
</table>

**Abstract**: Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**: Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Literature**: The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle / OLAT.
Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at “Lernmaterialien”

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Taught competencies

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

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Content
Structural and functional details of individual cell components, regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

551-0319-00L Cellular Biochemistry (Part I)

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>551-0319-00L</td>
<td>From DNA to Diversity (University of Zurich)</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Hajnal, D. Bopp</td>
</tr>
</tbody>
</table>

Abstract
The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analyzed model organisms.
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant assessed.

Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Script and original publications will be supplied during the course.

The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

By the end of this module, each student should be able to
- recognize the universal principles underlying the development of different animal body plans.
- explain how the genes encoding the molecular toolkit have evolved to create animal diversity.
- relate changes in gene structure or function to evolutionary changes in animal development.

Key skills:
By the end of this module, each student should be able to
- present and discuss a relevant evolutionary topic in an oral presentation
- select and integrate key concepts in animal evolution from primary literature
- participate in discussions on topics presented by others

Not assessed

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
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<tr>
<td>551-1303-00L</td>
<td>Cellular Biochemistry of Health and Disease</td>
<td>Lecture</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>Lecture</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>551-1171-00L</td>
<td>Immunology: From Milestones to Current Topics</td>
<td>Lecture</td>
<td>4</td>
<td>2</td>
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<tr>
<td>752-4009-00L</td>
<td>Molecular Biology of Foodborne Pathogens</td>
<td>Lecture</td>
<td>3</td>
<td>2</td>
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</table>

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 304 of 2345
The students should obtain an understanding of these processes, which are at work during gene expression. After completing this course, students will be able to understand:

- Disease concepts and consequences for research
- Basics about incidence, prevalence etc., and orphan indications

What is translational science and what is it not? How to identify need?

- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources

How to measure success?

- Outcome variables
- Improving the translational process

Challenges of communication?

- How independent is translational science?
- How academic conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.

Evolutionary Medicine for Infectious Diseases

Number of participants limited to 35.

Waiting list will be deleted 02.10.2022.

This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

The focus is on primary literature, but for some parts the following text books provide good background information:

Schmid Hempel 2011 Evolutionary Parasitology
Stearns & Medzhitov 2016 Evolutionary Medicine

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Biological Engineering and Biotechnology

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases is discussed.

Key skills
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
BIO142 Developmental Biology, BIO143 Neurobiology

376-1305-01L
Neural Systems for Sensory, Motor and Higher Brain Functions

W 3 credits 2V G. Schratt, J. Bohacek, R. Fiore, R. Polania, W. von der Behrens, J. Winterer, further lecturers

Abstract
The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

Objective
The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.

Content
The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle / OLAT.

551-0223-00L
Immunology III


Abstract
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of a immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies
Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective
Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines
Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice
Immunology I and II recommended but not compulsory
### Elective Major: Biochemistry

#### Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp</td>
</tr>
</tbody>
</table>

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

#### Compulsory Master Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>551-1303-00L</td>
<td>Cellular Biochemistry of Health and Disease</td>
<td>O</td>
<td>4</td>
<td>2S</td>
<td>V. Korkhov, T. Ishikawa, M. Jagannathan, R. Kroschewski, G. Neurohr, M. Peter, A. E. Smith, B. Snijder, K. Weis</td>
</tr>
</tbody>
</table>

**Number of participants limited to 20.**

**Abstract**
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

**Objective**
Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry.

**Content**
Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

**Literature**
The literature will be provided during the course.

**Prerequisites / notice**
The course will be taught in English.

#### Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

**Abstract**
D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course.

**Objective**
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

**Objective**
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytcs.

**Literature**
Basic:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barrassi, D. Bopp, A. Hajnal, O. Voigtet</td>
</tr>
</tbody>
</table>

**Abstract**
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

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Objective
The course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; assessment of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-0733-01L</td>
<td>Chemical Biology and Synthetic Biochemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>K. Lang</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.</td>
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<tr>
<td>Objective</td>
<td>Overview of enzymes, enzyme-catalyzed reactions and metabolic processes.</td>
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<tr>
<td>Content</td>
<td>Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.</td>
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<tr>
<td>Literature</td>
<td>A script will not be handed out.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Anologer Wissenstand, der in den Bachelor-Vorlesungen 'Nucleic Acids and Carbohydrates' und 'Proteins and Lipids' vermittelt wird, wird für diese Vorlesung vorausgesetzt.</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<td>Sensitivity to Diversity</td>
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<td></td>
<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni, M. Zampieri</td>
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<td>Number of participants limited to 15.</td>
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<tr>
<td>Abstract</td>
<td>Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.</td>
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<tr>
<td>Objective</td>
<td>Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.</td>
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<tr>
<td>Content</td>
<td>The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.</td>
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<tr>
<td>Lecture notes</td>
<td>Script and original publications will be supplied during the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.</td>
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<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td>Number of participants limited to 15.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).</td>
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<tr>
<td>Objective</td>
<td>The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.</td>
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<tr>
<td>Content</td>
<td>Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label &quot;Systems Biology&quot;, focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.</td>
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<tr>
<td>Lecture notes</td>
<td><a href="http://www.csb.ethz.ch/education/lectures.html">http://www.csb.ethz.ch/education/lectures.html</a></td>
<td></td>
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</tbody>
</table>
Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Taught competencies

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

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

<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
</tr>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Exercises are an integral part of the lecture.

Prerequisites:
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)" (or equivalent)
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

The students should obtain an understanding of these processes, which are at work during gene expression.

M. Fussenegger

W, M. Stoffel, further lecturers

Biological Engineering and Biotechnology Lecture Series I: Transcription & Processing & Translation

This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases. The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

F. Allain

3V

551-1407-00L

RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases. The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

J. Hall, M. Stoffel, further lecturers

2V

551-1409-00L

Cell Biophysics

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

T. Zambelli

4G

277-0939-00L
Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Taught competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies not assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management assessed

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

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

Cellular Matters: From Milestones to Open Questions

The number of participants is limited to 22 and will only take place with a minimum of 11 participants.
Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using in the subject: 551-0357-00.
In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

Abstract

In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Objective

In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).
As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.
With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

551-0357-00L

W 4 credits 2S


Autumn Semester 2022

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In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverers on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer's, Parkinson's, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

The presentations will be made available after the lectures. For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

### Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
<tr>
<td>Abstract</td>
<td>Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.</td>
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<tr>
<td>Objective</td>
<td>Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Scripts on the individual topics can be found under <a href="http://www.mol.biol.ethz.ch/teaching">http://www.mol.biol.ethz.ch/teaching</a>.</td>
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<tr>
<td>Literature</td>
<td>Current topics: References will be given during the lectures.</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
<tr>
<td>Abstract</td>
<td>Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<tr>
<td>Objective</td>
<td>This course focuses on the concepts of classical and modern genetics and genomics.</td>
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<tr>
<td>Content</td>
<td>The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<tr>
<td>Literature</td>
<td>Scripts and additional material will be provided during the semester.</td>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
<tr>
<td>Abstract</td>
<td>Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Objective</td>
<td>This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Content</td>
<td>Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Literature</td>
<td>Updated handouts will be provided during the class.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Current literature references will be provided during the lectures.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>English</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prequisites / notice</td>
<td>The lecture &quot;Grundlagen der Biologie II: Mikrobiologie&quot; is the basis for this advanced lecture.</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Basic knowledge of the mechanisms and the regulation of an immune response.</td>
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</tbody>
</table>

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 312 of 2345
Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Taught competencies
Subject-specific Competencies
- Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Social Competencies
- Communication
- Cooperation and Teamwork

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

Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Problem-solving
- Media and Digital Technologies
- Project Management

Project Management
- Project Management

Communication
- Communication

Cooperation and Teamwork
- Cooperation and Teamwork

Social Competencies
- Communication
- Cooperation and Teamwork

Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Critical Thinking
- Critical Thinking

Integrity and Work Ethics
- Integrity and Work Ethics

Self-awareness and Self-reflection
- Self-awareness and Self-reflection

Self-direction and Self-management
- Self-direction and Self-management

Adaptability and Flexibility
- Adaptability and Flexibility

Creative Thinking
- Creative Thinking

Self-direction and Self-management
- Self-direction and Self-management

Sensitivity to Diversity
- Sensitivity to Diversity

Negotiation
- Negotiation

529-0731-00L Nucleic Acids and Carbohydrates
Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

Abstract
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content

Lecture notes
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Elective Major: Molecular Plant Biology

Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0120-00L</td>
<td>Plant Biology Colloquium (Autumn Semester)</td>
<td>W</td>
<td>2</td>
<td>1K</td>
<td>S. C. Zeeman, K. Bomblies, C. Sánchez-Rodríguez, O. Voinnet</td>
</tr>
</tbody>
</table>

Abstract
Current topics in Molecular Plant Biology presented by internal and external speakers from academia.

Objective
Getting insight into actual areas and challenges of Molecular Plant Biology.

Content
Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0311-00L</td>
<td>Molecular Life of Plants</td>
<td>O</td>
<td>6</td>
<td>4V</td>
<td>S. C. Zeeman, K. Bomblies, C. Sánchez-Rodríguez, O. Voinnet</td>
</tr>
</tbody>
</table>

Abstract
The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.

Objective
The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.

Content
The course "Molecular Life of Plants" will cover the following topics:

- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
- Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
- Senescence

Elective Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
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<tr>
<td></td>
<td>and Function</td>
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<tr>
<td></td>
<td>D-BIOL students are obliged to take part I and part II (next semester)</td>
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</tbody>
</table>

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
</tbody>
</table>

Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.
Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Prerequisites / notice
!English!
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

551-0319-00L

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
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<tr>
<td><strong>Objective</strong></td>
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<tr>
<td>Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division &amp; growth, and cell migration.</td>
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<tr>
<td><strong>Content</strong></td>
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<tr>
<td>The full-year course (551-0319-00 &amp; 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.</td>
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<tr>
<td>The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td>No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts).</td>
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<tr>
<td>Lecture notes</td>
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<tr>
<td>Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (<a href="mailto:alicia.smith@bc.biol.ethz.ch">alicia.smith@bc.biol.ethz.ch</a>)</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.</td>
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<tr>
<td>Literature</td>
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<tr>
<td>To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.</td>
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</table>

701-2413-00L

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolutionary Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
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<tr>
<td><strong>Objective</strong></td>
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<tr>
<td>The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).</td>
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<tr>
<td><strong>Content</strong></td>
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<tr>
<td>The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.</td>
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<tr>
<td>Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.</td>
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<tr>
<td>Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem.</td>
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<tr>
<td>Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td>No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).</td>
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<tr>
<td>Literature</td>
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529-0731-00L

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Nucleic Acids and Carbohydrates</td>
<td>W</td>
<td>6</td>
<td>3G</td>
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<tr>
<td><strong>Objective</strong></td>
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<tr>
<td>Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.</td>
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<tr>
<td><strong>Content</strong></td>
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<tr>
<td>Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
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<tr>
<td>No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Mainly based on original literature, a detailed list will be distributed during the lecture</td>
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<tr>
<td><strong>Subject-specific Competencies</strong></td>
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<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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**E elective Compulsory Master Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0733-01L</td>
<td>Chemical Biology and Synthetic Biochemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>K. Lang</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td><strong>Objective</strong></td>
<td></td>
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<tr>
<td>Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.</td>
<td>Overview of enzymes, enzyme-catalyzed reactions and metabolic processes.</td>
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</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 315 of 2345
Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.

A script will not be handed out.

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.


Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Analytical Competencies: assessed

- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

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

Personal Competencies

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

Insect Ecology

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

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

- Provided to students through Moodle

Systems Biology of Metabolism

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

- Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

- The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

- Script and original publications will be supplied during the course.

Plant Pathology I

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

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

Lecture Topics and Tentative Schedule

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

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

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

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

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

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


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

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

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


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

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

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

Elective Courses

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

Abstract: Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective: Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes: Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and recombination; analysis of developmental processes; epigenetics and RNA interference.

Current literature references will be provided during the lectures.

***Basics:***
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-special-students-university-of-zurich.html/

**Abstract**
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**
This course focuses on the concepts of classical and modern genetics and genomics.

**Content**
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**
Scripts and additional material will be provided during the semester.

<table>
<thead>
<tr>
<th>Course Number</th>
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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>551-0319-00L</td>
<td>Celluar Biochemistry (Part I)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp</td>
</tr>
</tbody>
</table>

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Lecture notes**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

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**Elective Major: Systems Biology**

**Elective Compulsory Concept Courses**

See D-BIOL Master Studies Guide

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 318 of 2345
This course focuses on the concepts of classical and modern genetics and genomics.

Content

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes

Scripts and additional material will be provided during the semester.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>ECTS</th>
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</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4U</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>

Abstract

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective

This course focuses on the concepts of classical and modern genetics and genomics.

Content

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes

Scripts and additional material will be provided during the semester.
Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Objective
- Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems.
- Provide an introduction to dynamical system and covers the mathematical analysis of pattern formation in growing, developing systems as well as the description of mechanical effects at the cell and tissue level.

Content
1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Literature
The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:
- Murray, Mathematical Biology, Springer
- Forgacs and Newman, Biological Physics of the Developing Embryo, CUP
- Keener and Sneyd, Mathematical Physiology, Springer
- Fall et al., Computational Cell Biology, Springer
- Szallasi et al.; System Modeling in Cellular Biology, MIT Press
- Wolkenhauer, Systems Biology

Prerequisites / notice
The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

ELECTIVE COMPULSORY MASTER COURSES II: BIOLOGY

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4 credits</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni, M. Zampieri</td>
</tr>
</tbody>
</table>

Objective
- Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content
- The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics.
- For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes
Script and original publications will be supplied during the course.

Prerequisites / notice
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0571-00L</td>
<td>From DNA to Diversity (University of Zurich)</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Hajnal, D. Bopp</td>
</tr>
</tbody>
</table>

Objective
- By the end of this module, each student should be able to:
  - recognize the universal principles underlying the development of different animal body plans.
  - explain how the genes encoding the molecular toolkit have evolved to create animal diversity.
  - relate changes in gene structure or function to evolutionary changes in animal development.

Key skills:
- By the end of this module, each student should be able to:
  - present and discuss a relevant evolutionary topic in an oral presentation.
  - select and integrate key concepts in animal evolution from primary literature.
  - participate in discussions on topics presented by others.

Data: 18.08.2022 12:39
Autumn Semester 2022
Content
Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

Lecture notes
No.

Literature

Prerequisites / notice
Prerequisites: Basic mathematics (linear algebra, calculus, probability)

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>assessed</td>
<td>Problem-solving</td>
<td></td>
<td>Self-direction and Self-management</td>
</tr>
<tr>
<td>assessed</td>
<td></td>
<td></td>
<td>not assessed</td>
</tr>
</tbody>
</table>

227-0939-00L Cell Biophysics W 6 credits 4G T. Zambelli

Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life's mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content
• Basics of theory of probability
• Boltzmann's law
• Entropy maximization and Gibbs free energy minimization
• Ligand-receptor: two-state systems and the MWC model
• Random walks, diffusion, crowding
• Electrostatics for salty solutions
• Elasticity: fibers and membranes
• Molecular motors
• Action potential: Hodgkin-Huxley model
• Photosynthesis and vision
• Gene regulation
• Development: Turing patterns
• Sequences and evolution

Lecture notes
Theory and corresponding exercises are merged together during the classes.

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

Literature

Prerequisites / notice
Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.
Microbiology (Part I)

- Taught competencies
  - Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
  - Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving

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

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

- Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

- Adaptability and Flexibility
- Communication
- Social Competencies
- Personal Competencies

Elective Major: Molecular and Structural Biology

Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

Data: 18.08.2022 12:39
551-0309-00L Concepts in Modern Genetics  
Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIOC348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

| Abstract | Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference. |
| Objective | This course focuses on the concepts of classical and modern genetics and genomics. |
| Content | The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference. |
| Lecture notes | Scripts and additional material will be provided during the semester. |

551-1299-00L Bioinformatics  
6 credits

| Abstract | Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioinformatics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century. |
| Objective | Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology. |
| Prerequisites / notice | Course participants have already acquired basic programming skills in Python and R. |
| Literature | Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN. |
| Taught competencies | Self-direction and Self-management |

529-0731-00L Nucleic Acids and Carbohydrates  
Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

| Abstract | Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines |
| Objective | Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines |
| Literature | Mainly based on original literature, a detailed list will be distributed during the lecture |

### Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0733-01L</td>
<td>Chemical Biology and Synthetic Biochemistry</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>K. Lang</td>
</tr>
</tbody>
</table>

| Abstract | Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies. |
| Objective | Overview of enzymes, enzyme-catalyzed reactions and metabolic processes. |
| Content | Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies. |
| Lecture notes | A script will not be handed out. |
| Literature | Citations from the original literature relevant to the individual lectures will be assigned during the lectures. |
| Prerequisites / notice | Analogues Wissensstand, der in den Bachelor-Vorlesungen 'Nucleic Acids and Carbohydrates' und 'Proteins and Lipids' vermittelt wird, wird für diese Vorlesung vorausgesetzt. |
Classical Simulation of (Bio)Molecular Systems

4 credits
2V+1U

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts. The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good understanding of lab exercises and of concepts of single-cell metabolic networks. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics. For more information about the course: https://www.olat.uzh.ch/olat/auth/repo/go?rid=600670219

Methods and techniques in classical (atomic) computer simulations of (bio)molecular systems.

Objectives

1. To understand basic concepts in classical computer simulations of (bio)molecular systems.
2. To become acquainted with the theory and the practical implementation of classical computer simulations.
3. To develop the ability to interpret the results of classical computer simulations.
4. To be able to apply classical computer simulations to solve problems in the fields of molecular biology and chemistry.

Content

1. Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology.
2. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Prerequisites / notice

Solid knowledge in biochemistry strongly recommended.

Lecturer

M. Dettling

Literature

PDFs will be available on OLAT server.

551-1401-00L Advanced Protein Engineering (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BCH420

Restricted to max. 10 students from ETH

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract

Introduction into current research strategies in protein science.

Method-specific Competencies

- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

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

Personal Competencies

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

Objective

To understand current research strategies in protein science.

Content

Proteins have become an object of intense study in modern science, ranging from their use as therapeutics to elucidating their structure and function in the cell. Moreover, it is now possible to engineer and evolve tailor-made proteins, opening up many new areas of science. This course will attempt to cover the frontiers and remaining challenges, emphasizing the biochemical foundations of the various approaches. To understand current research strategies in protein science.

Lecture notes

Slides and references will be available on OLAT server.

Literature

https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Prerequisites / notice

Solid knowledge in biochemistry strongly recommended.

Lecturer

P. H. Hünenberger, J. Dolenc, S. Riniker

551-1153-00L Systems Biology of Metabolism

Number of participants limited to 15.

Abstract

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective

To understand current research strategies in protein science.

Content

Proteins have become an object of intense study in modern science, ranging from their use as therapeutics to elucidating their structure and function in the cell. Moreover, it is now possible to engineer and evolve tailor-made proteins, opening up many new areas of science. This course will attempt to cover the frontiers and remaining challenges, emphasizing the biochemical foundations of the various approaches. To understand current research strategies in protein science.

Lecture notes

Slides and references will be available on OLAT server.

Literature

https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Prerequisites / notice

Solid knowledge in biochemistry strongly recommended.

Lecturer

U. Sauer

N. Zamboni, M. Zampieri

529-0004-01L Classical Simulation of (Bio)Molecular Systems

Abstract

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective

Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature

See: www.csms.ethz.ch/education/CSBMS

Prerequisites / notice

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

401-0649-00L Applied Statistical Regression

Abstract

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective

To understand regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Content

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Lecture notes

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BCH420

Restricted to max. 10 students from ETH

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract

Introduction into current research strategies in protein science.

Method-specific Competencies

- Techniques and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

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

Personal Competencies

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

Objective

To understand current research strategies in protein science.

Content

Proteins have become an object of intense study in modern science, ranging from their use as therapeutics to elucidating their structure and function in the cell. Moreover, it is now possible to engineer and evolve tailor-made proteins, opening up many new areas of science. This course will attempt to cover the frontiers and remaining challenges, emphasizing the biochemical foundations of the various approaches. To understand current research strategies in protein science.

Lecture notes

Slides and references will be available on OLAT server.

Literature

https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Prerequisites / notice

Solid knowledge in biochemistry strongly recommended.

Lecturer

P. H. Hünenberger, J. Dolenc, S. Riniker

551-1153-00L Systems Biology of Metabolism

Number of participants limited to 15.

Abstract

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective

To understand current research strategies in protein science.

Content

Proteins have become an object of intense study in modern science, ranging from their use as therapeutics to elucidating their structure and function in the cell. Moreover, it is now possible to engineer and evolve tailor-made proteins, opening up many new areas of science. This course will attempt to cover the frontiers and remaining challenges, emphasizing the biochemical foundations of the various approaches. To understand current research strategies in protein science.

Lecture notes

Slides and references will be available on OLAT server.

Literature

https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Prerequisites / notice

Solid knowledge in biochemistry strongly recommended.

Lecturer

U. Sauer

N. Zamboni, M. Zampieri

529-0004-01L Classical Simulation of (Bio)Molecular Systems

Abstract

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective

Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature

See: www.csms.ethz.ch/education/CSBMS

Prerequisites / notice

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

401-0649-00L Applied Statistical Regression

Abstract

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.
The course provides the first part of an introduction to the statistical software R for scientists. Topics covered are
assessed
The last third of the course is dedicated to an introduction to generalized linear models; this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and Poisson regression for count data.

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The course aims to facilitate this by providing a basic introduction to R.

The course resources will be provided via the Moodle web learning platform.

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

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

The students, but also the classes will be based on procedures from the freely available, open-source statistical software package R.

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

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

The course resources will be provided via the Moodle web learning platform.

As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15518

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

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

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models; this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and Poisson regression for count data.

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

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

The course resources will be provided via the Moodle web learning platform.

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- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org
This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature. Does not take place this semester.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation. Does not take place this semester.

Theory and corresponding exercises are merged together during the classes.
Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Taught competencies

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

Social Competencies

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

Personal Competencies

| Adaptable and Flexibility    | assessed              |         |
| Creative Thinking            | assessed              |         |
| Critical Thinking            | assessed              |         |
| Integrity and Work Ethics    | assessed              |         |
| Self-awareness and Self-reflection | assessed |         |
| Self-direction and Self-management | assessed |         |

Elective Major: Biological Chemistry

Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0733-01L</td>
<td>Chemical Biology and Synthetic Biochemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>K. Lang</td>
</tr>
</tbody>
</table>

Abstract

Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.

Objective

Overview of enzymes, enzyme-catalyzed reactions and metabolic processes.

Content

Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.

Lecture notes

A script will not be handed out.

Literature

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.
Analoges Wissenstand, der in den Bachelor-Vorlesungen ‘Nucleic Acids and Carbohydrates’ und ‘Proteins and Lipids’ vermittelt wird, wird für diese Vorlesung vorausgesetzt.

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

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

529-0004-01L  Classical Simulation of (Bio)Molecular Systems  W  6 credits  4G  P. H. Hünenberger, J. Dolenc, S. Riniker

Abstract
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective
Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature
See: www.csms.ethz.ch/education/CSBMS

529-0233-01L  Organic Synthesis: Methods and Strategies  W  6 credits  3G  E. M. Carreira

Abstract
The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

Objective
Extension and deepening of the knowledge in organic synthesis and the principles of structure and reactivity.

Content

Literature

Prerequisites
OC I-IV

529-0243-01L  Transition Metal Catalysis: From Mechanisms to Applications  W  6 credits  3G  B. Morandi

Abstract
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint.

Prerequisites
OC I-IV
Objective
Understanding and critical evaluation of current research in transition metal catalysis. Design of mechanistic experiments to elucidate reaction mechanisms. Synthetic relevance of transition metal catalysis. Students will also learn about writing an original research proposal during a workshop.

Content
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint. Synthetic applications of these reactions. Introduction and application of tools for the elucidation of mechanisms. Selected examples of topics include: C-H activation, C-O activation, C-C activation, redox active ligands, main group redox catalysis, bimetallic catalysis.

Lecture notes
Lecture slides will be provided online. A Handout summarizing important concepts in organometallic and physical organic chemistry will also be provided. Useful references and handouts will also be provided during the workshop.

Literature
Primary literature and review articles will be cited during the course.

The following textbooks can provide useful support for the course:

Prerequisites / notice
Required level: Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACIII

Special requirement: each participant will have to come up with an independent research proposal to be presented orally (or handed in in written form) at the end of the semester. A dedicated workshop will be organized in the middle of the semester to introduce the students to proposal writing and presentation.

529-0041-00L  Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics  W  6 credits  3G  R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano

Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging.

Lecture notes
Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Lecture notes will be made available online. Useful references and handouts will also be provided during the workshop.

529-0051-00L  Analytische Chemie I (3. Semester)  W  6 credits  3G  M. Fussenegger

Abstract
529-0058-00L  Analytische Chemie II (4. Semester)  W  6 credits  3G

(529-0081-00L  Analytische Chemie II (4. Semester)  W  6 credits  3G

Taught competencies

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

Method-specific Competencies

Social Competencies

Personal Competencies

Assessed
Assessed
Not Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed

529-0240-00L  Chemical Biology - Peptides  W  6 credits  3G  H. Wennemers

Abstract
An advanced course on the synthesis, properties and function of peptides in chemistry and biology.

Objective
Knowledge of the synthesis, properties and function of peptides in chemistry and biology.

Content
Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.

Lecture notes
Citations from the original literature relevant to the individual lectures will be assigned weekly.

Literature

536-0108-00L  Biological Engineering and Biotechnology  W  4 credits  3V  M. Fussenegger

Abstract
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

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**Adaptability and Flexibility**

RNA Biology Lecture Series I: Transcription & Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; not assessed

**F. Allain**

Transcription & 3’end formation; splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP

The students should obtain an understanding of these processes, which are at work during gene expression.

**Concepts and Theories**

Cell Biophysics

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results. By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

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**Table: Lecture Notes**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1407-00L</td>
<td>RNA Biology Lecture Series I: Transcription &amp; Processing &amp; Translation</td>
<td>W</td>
<td>4</td>
<td>F. Allain, N. Ban, U. Kutay, further lecturers</td>
</tr>
<tr>
<td>551-1409-00L</td>
<td>RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics</td>
<td>W</td>
<td>4</td>
<td>J. Hall, M. Stoffel, further lecturers</td>
</tr>
<tr>
<td>529-0241-10L</td>
<td>Selectivity in Organic Synthesis</td>
<td>W</td>
<td>6</td>
<td>J. W. Bode</td>
</tr>
<tr>
<td>227-0939-00L</td>
<td>Cell Biophysics</td>
<td>W</td>
<td>6</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>

**Prerequisites / notice**

Basic knowledge of cell and molecular biology.

**Note:** Does not take place this semester.
Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of:

- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Taught competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

551-0357-00L Cellular Matters: From Milestones to Open Questions

The number of participants is limited to 22 and will only take place with a minimum of 11 participants. Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using in the subject: 551-0357-00. In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

Abstract

In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Objective

In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.


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Content

In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverons on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:

1) a short literature seminar; Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.

2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Lecture notes

The presentations will be made available after the lectures.

Literature

The milestone papers will be provided in advance.

>>>> Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
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<tr>
<td></td>
<td>D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course</td>
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<tr>
<td>Abstract</td>
<td>Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.</td>
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<tr>
<td>Objective</td>
<td>Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanlytics.</td>
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<tr>
<td>Literature</td>
<td>Scripts on the individual topics can be found under <a href="http://www.mol.biol.ethz.ch/teaching">http://www.mol.biol.ethz.ch/teaching</a>.</td>
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<tr>
<td>Literature</td>
<td>Basics:</td>
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<td></td>
<td>- Creighton, T.E., Proteins, Freeman, (1993)</td>
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<td></td>
<td>- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.</td>
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<tr>
<td>Content</td>
<td>Structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions.</td>
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<tr>
<td></td>
<td>In particular, they will learn to explain the integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division &amp; growth, and cell migration.</td>
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<tr>
<td></td>
<td>Students will describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions.</td>
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<td></td>
<td>Students will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.</td>
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<tr>
<td>Literature</td>
<td>Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.</td>
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<tr>
<td>Literature</td>
<td>To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.</td>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp</td>
</tr>
<tr>
<td>Abstract</td>
<td>Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division &amp; growth, and cell migration.</td>
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<tr>
<td>Objective</td>
<td>The full-year course (551-0319-00 &amp; 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.</td>
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<td>The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions.</td>
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<td>In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytokoskeletal rearrangements, cell motility, cell division and cell growth.</td>
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<td>In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.</td>
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<tr>
<td>Content</td>
<td>Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.</td>
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<td>Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.</td>
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<tr>
<td>Lecture notes</td>
<td>Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (<a href="mailto:alicia.smith@bc.biol.ethz.ch">alicia.smith@bc.biol.ethz.ch</a>)</td>
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<tr>
<td>Literature</td>
<td>To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.</td>
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</tr>
</thead>
<tbody>
<tr>
<td>551-1299-00L</td>
<td>Bioinformatics</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>S. Sunagawa, P. Beltrao, A. Blasimme, A. Kahles, C. von Mering, N. Zamboni</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.</td>
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<tr>
<td>Objective</td>
<td>Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barrat, D. Bopp, A. Hajnal, O. Voissenet</td>
</tr>
<tr>
<td>Information for UZH students:</td>
<td>Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.</td>
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<tr>
<td>Please mind the ETH enrolment deadlines for UZH students:</td>
<td><a href="https://www.ethz.ch/en/studies/undergraduate-courses/special-degree-courses/special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/undergraduate-courses/special-degree-courses/special-students-university-of-zurich.html</a></td>
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</tbody>
</table>
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

This course focuses on the concepts of classical and modern genetics and genomics.

Scripts and additional material will be provided during the semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0180-00L</td>
<td>Research Ethics</td>
<td>W+</td>
<td>2</td>
<td>2G</td>
<td>G. Achermann, P. Emch</td>
</tr>
</tbody>
</table>

Recommended Elective Courses (for all Master Majors)

- Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

- Participants of the course Research Ethics will
  - Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
  - Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

- Participants will learn
  - I. Introduction to Moral Reasoning
    - 1. Ethics - the basics
      - 1.1 What ethics is not...
      - 1.2 Recognising an ethical issue (awareness)
      - 1.3 What is ethics? Personal, cultural and ethical values, principles and norms
      - 1.4 Ethics: a classification
      - 1.5 Research Ethics: what is it and why is it important?
    - 2. Normative Ethics
      - 2.1 What is normative ethics?
      - 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories
      - 2.3 The plurality of normative theories (moral pluralism)
      - 2.4 Roles of normative theories in “Research Ethics”

  - 3. Decision making: How to solve a moral dilemma
    - 3.1 How (not) to approach ethical issues
    - 3.2 What is a moral dilemma? Is there a correct method for answering moral questions?
    - 3.3 Methods of making ethical decisions
    - 3.4 Is there a “right” answer?

  - II. Research Ethics - Internal responsibilities
    - 1. Integrity in research and research misconduct
    - 1.1 What is research integrity and why is it important?
    - 1.2 What is research misconduct?
    - 1.3 Questionable/Detrimental Research Practice (QRP/DRP)
    - 1.4 What is the incidence of misconduct?
    - 1.5 What are the factors that lead to misconduct?
    - 1.6 Responding to research wrongdoing
    - 1.7 The process of dealing with misconduct

  - 2. Data Management
    - 2.1 Data collection and recordkeeping
    - 2.2 Analysis and selection of data
    - 2.3 The (mis)representation of data
    - 2.4 Ownership of data

  - 3. Publication ethics / Responsible publishing
    - 3.1 Background
    - 3.2 Criteria for being an author
    - 3.3 Ordering of authors

  - III. Research Ethics – External responsibilities
    - 1. Research involving human subjects
    - 1.1 History of research with human subjects
    - 1.2 Basic ethical principles – The Belmont Report
    - 1.3 Requirements to make clinical research ethical
    - 1.4 Social value and scientific validity
    - 1.5 Selection of study participants – the concept of vulnerability
    - 1.6 Favourable risk-benefit ratio
    - 1.7 Independent review - Ethics Committees
    - 1.8 Informed consent
    - 1.9 Respect for potential and enrolled participants

- Particularly suitable for students of D-BIOL, D-CHAB, D-HEST

- Number of participants limited to 40

- Lecture notes
  - Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.
Prerequisites / notice

What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...).

Taught competencies

Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Decision-making
Problem-solving
Method-specific Competencies
Social Competencies
Communication
Cooperation and Teamwork
Personal Competencies
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

Research Projects (for all Master Majors)

Research projects neither accepted nor registered nor approved will not be credited.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1801-00L</td>
<td>Research Project I</td>
<td>O</td>
<td>15 credits</td>
<td>34A</td>
<td>Lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Research projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.</td>
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<tr>
<td>551-1801-01L</td>
<td>Research Project II</td>
<td>O</td>
<td>15 credits</td>
<td>34A</td>
<td>Lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Research projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.</td>
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Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BIOL

see Science in Perspective: Language Courses ETH/UZH

Master’s Thesis

A Master’s thesis neither accepted nor registered nor approved will not be credited.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1800-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>
| Only students who fulfill the following criteria are allowed to begin with their master thesis:
  a. successful completion of the bachelor programme;
  b. fulfilling of any additional requirements necessary to gain admission to the master programme;
  c have acquired at least 30 credits in the category "research projects". |
| Abstract   | The Master research will be carried out on a theme in the chosen subject area and must be completed with a written report (Thesis) within six months |

Master’s Examination

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1800-01L</td>
<td>Master’s Examination</td>
<td>O</td>
<td>4 credits</td>
<td></td>
<td>Lecturers</td>
</tr>
</tbody>
</table>
| Only students who fulfill the following criteria are admitted for the master examination:
  a. successful completion of the bachelor programme;
  b. fulfilling of any additional requirements necessary to gain admission to the master programme. |
| Abstract   | In the Master’s examination a student must provide proof of general knowledge in the elective major field. Starting with a discussion based on the Master’s thesis further experiments and experimental strategies should be discussed in order to test the general understanding. |

Biology Master - Key for Type

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

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Lecture notes: The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice: The lecture will be taught in English.

151-0605-00L  Nanosystems  W  4 credits  4G  A. Stemmer
Abstract: From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures.
Objective: Familiarize students with basic science and engineering principles governing the nano domain.
Content: The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected. Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:
(I) From Quantum to Continuum
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

Literature:

Prerequisites / notice: Course format:
Lectures and Mini-Review presentations: Thursday 10-13
Homework: Mini-Review (compulsory continuous performance assessment)
Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

151-0621-00L  Microsystems I: Process Technology and Integration  W  6 credits  3V+3U  M. Haluska, C. Hierold
Abstract: Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).
Objective: Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).
Content:
- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.
- Application of selected technologies will be demonstrated on case studies.

Lecture notes: Handouts (available online)
Literature
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice
Prerequisites: Physics I and II

227-0105-00L
Introduction to Estimation and Machine Learning
W 6 credits 4G H.-A. Loeliger

Abstract
Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

Objective
Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Content
Review of probability theory;
basics of statistical estimation;
least squares and linear learning;
Hilbert spaces;
singular-value decomposition;
kernel methods, neural networks, and more

Lecture notes
Lecture notes will be handed out as the course progresses.

Prerequisites / notice
solid basics in linear algebra and probability theory

227-0311-00L
Qubits, Electrons, Photons
W 6 credits 3V+2U T. Zambelli

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!!).

Content
• Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
• Postulates of QM: Hilbert Spaces and Operators
• Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
• Density Operator
• Spin: Qubits, Bloch Equations, and NMR
• Entanglement
• Symmetries and Corresponding Operators
• Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
• Harmonic Oscillator: Creation and Annihilation Operators
• Identical Particles: Bosons and Fermions
• Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
• Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Old copies:

!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature
• M. Le Bellac, "Quantum Physics", 2011, Cambridge University Press

Supplementary material will be uploaded in Moodle.

———

+ (as rigorous and profound presentation of the mathematical framework) G. Dell'Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer

+ (as account of those formidable years) G. Gamow, "Thirty Years that Shook Physics", 1985, Dover Publications Inc.

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II":

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed/Not Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Not assessed</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Assessed/Not Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptability and Flexibility</td>
<td>Assessed</td>
</tr>
<tr>
<td>Creative Thinking</td>
<td>Assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>Assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>Assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>Assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>Assessed</td>
</tr>
</tbody>
</table>

### Biomedical Imaging
- **W 6 credits 5G**
- **S. Kozerke, K. P. Prüssmann**

**Abstract**
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

**Objective**
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

**Content**
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

**Lecture notes**
Lecture notes and handouts

**Literature**
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

**Prerequisites / notice**
Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

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### Biomedical Engineering
- **W 4 credits 3G**
- **J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong**

**Abstract**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**
- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes**
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

**AND**

**Prerequisites / notice**
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Taught
competencies

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

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving not assessed
- Project Management not assessed

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

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

Method-specific Competencies

Analytical Competencies
- Decision-making assessed

Techniques and Technologies assessed
- Media and Digital Technologies not assessed
- Problem-solving not assessed
- Project Management not assessed

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

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

Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field

Content
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning
- Plonsky and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Literature

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
Objective
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers. After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to ‘error backpropagation’ in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples; they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes
The lecture slides will be provided as a PDF after each lecture.

Prerequisites / notice
This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

227-1037-00L Introduction to Neuroinformatics W 6 credits 2V+1U+1A V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens

Abstract
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content
This course considers the structure and function of biological neuronal networks at different levels. The function of neuronal networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of how action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

376-1714-00L Biocompatible Materials W 4 credits 3V K. Manuria, M. Rottmar, M. Zenobi-Wong

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature
(available online via ETH library)

Handouts and references therin.
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinetic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

### Recommended Elective Courses

These courses are particularly recommended for the Bioelectronics track. Please consult your track advisor if you wish to select other subjects.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Ahmed</td>
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<tr>
<td></td>
<td>Note: The previous course title until HS21 “Microscale Acoustofluidics”</td>
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**Abstract**
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robots.

**Objective**
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

**Content**
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

**Lecture notes**

**Literature**

**Prerequisites / notice**
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

**Teaught competencies**

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<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<td>Project Management</td>
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**Social Competencies**

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<td>Sensitivity to Diversity</td>
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**Personal Competencies**

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<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
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<td>Self-direction and Self-management</td>
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</table>

**Number** 151-0601-00L **Theory of Robotics and Mechatronics**

*Does not take place this semester.*

**Abstract**
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.
Content
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Lecture notes
available.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Lecture Notes</th>
<th>Credits</th>
<th>Semester</th>
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</thead>
<tbody>
<tr>
<td>151-0905-00L</td>
<td>Medical Technology Innovation - From Concept to Clinics</td>
<td>available.</td>
<td>4 credits</td>
<td>W</td>
</tr>
</tbody>
</table>

Abstract
Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

Objective
After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

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Literature
will be available on the moodle.

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<td>151-0913-00L</td>
<td>Introduction to Photonics</td>
<td>4 credits</td>
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Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts
Literature
Optics (Hecht) - Pearson
Prerequisites / notice
Physics I, Physics II

227-1033-00L Neurromorphic Engineering I W 6 credits 2V+3U T. Delbrück, G. Indiveri, S.-C. Liu

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INH404 at UZH. Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.

Content
Neurromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neurromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neurromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neurromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.
### Prerequisites
- Knowledge of the Laplace transform and z-transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria)
- Background in basics of semiconductor physics helpful, but not required.

### 227-0166-00L Analog Integrated Circuits
**W** 6 credits 2V+2U  T. Jang

| **Abstract** | This course provides a foundation in analog circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems. The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

**Content** | Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc.; Amplifiers; differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

**Lecture notes** | Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature** | Behzad Razavi, Design of Analog CMOS Integrated Circuits (Irwin Electronics & Computer Engineering) 1st or 2nd edition, McGraw-Hill Education

### 227-0447-00L Image Analysis and Computer Vision
**W** 6 credits 3V+1U  E. Konukoglu, F. Yu


**Objective** | Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content** | This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

**Lecture notes** | Course material Script, computer demonstrations, exercises and problem solutions

**Prerequisites / notice** | Prerequisites:
- Basic concepts of mathematical analysis and linear algebra.
- The computer exercises are based on Python and Linux.
- The course language is English.

### 227-0468-00L Analog Signal Processing and Filtering
**W** 6 credits 2V+2U  H. Schmid

| **Abstract** | Suitable for Master Students as well as Doctoral Students.
- This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

**Objective** | This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

**Content** | At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor managers follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

**Lecture notes** | The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

### Prerequisites / notice
- The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.
- Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lectures.

### Prerequisites
- Suitable for Master Students as well as Doctoral Students.
- Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

**Details:** https://people.ee.ethz.ch/~haschmid/asfwiki/

- The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

- Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

- Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...), and of the main properties of linear systems is necessary.
The course covers the status and prospects of post-silicon memory technologies, such as PCM, RRAM, STT-MRAM and FeRAM, and others. Students learn and compare these future memory technologies by means of interactive lectures, group projects, and laboratory sessions. The course employs constructive alignment and active learning teaching concepts.

Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other’s. Selecting to study one technology in more details, students will evaluate its potential and acquire important presenting and critical thinking skills.

Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 3 presentations (20-25 min each), followed the example given by the lecturer.

Lecture notes will be made available on the website.
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

• Basics of theory of probability
• Boltzmann’s law
• Entropy maximization and Gibbs free energy minimization
• Ligand-receptor: two-state systems and the MWC model
• Random walks, diffusion, crowding
• Electrostatics for salty solutions
• Elasticity: fibers and membranes
• Molecular motors
• Action potential: Hodgkin-Huxley model
• Photosynthesis and vision
• Gene regulation
• Development: Turing patterns
• Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o’clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!

Literature


Prerequisites / notice

Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Taught competencies

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

Computational Psychiatry & Computational Psychosomatics

Does not take place this semester.

Number of participants limited to 24.

Information for UZH students:
Enrolment to this course unit only possible at ETH Zurich.
No enrolment to module BMT20002.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Abstract

This seminar deals with the development of clinically relevant computational tools and/or their application to psychiatry and psychosomatics. It is complementary to the annual Computational Psychiatry Course and serves to build bridges between computational scientists and clinicians. It is designed to foster in-depth exchange, with ample time for discussion.

Objective

Understanding strengths and weaknesses of current trends in the development of clinically relevant computational tools and their application to problems in psychiatry and psychosomatics.
This seminar deals with the development of computational tools (e.g. generative models, machine learning) and/or their application to psychiatry and psychosomatics. The seminar includes (i) presentations by computational scientists and clinicians, (ii) group discussion with focus on methodology and clinical utility, (iii) self-study based on literature provided by presenters.

Literature

For additional self-study of the topics presented in this seminar will be provided by the presenters and will be available online at https://www.tnu.ethz.ch/en/teaching.

Prerequisites / notice

Participants are expected to be familiar with general principles of statistics (including Bayesian statistics) and have successfully completed the course "Computational Psychiatry" (Course number 227-0971-00L).

227-2037-00L

Physical Modelling and Simulation

Abstract

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetical analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

263-5702-00L

Seminar on Digital Humans

Number of participants limited to 24.

The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract

This seminar covers advanced topic in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

Objective

The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills.

Content

This seminar covers advanced topics in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.

Literature

Individual research papers are selected each term. See https://vlg.inf.ethz.ch/ and http://graphics.ethz.ch/ for example papers.

263-5902-00L

Computer Vision

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective

The objectives of this course are:

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

376-1103-00L

Frontiers in Nanotechnology

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.
Abstract
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Objective
Objective 1:
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2:
Acquire skills to design novel non-invasive technologies for sport and health.

Content
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

376-1219-00L

W 3 credits
2V
R. Riener, O. Lambercy

Abstract
Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces
Literature

Introductory Books:


Selected Journal Articles and Web Links:


Prerequisites / notice

- Students of other departments, faculties, courses are also welcome

Objective

- The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

376-1351-00L Micro/Nanotechnology and Microfluidics for Biomedical Applications

<table>
<thead>
<tr>
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<tr>
<td>2V</td>
<td>E. Delamarche</td>
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</tbody>
</table>

Abstract

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.
Biomicrofluidic Engineering

Number of participants limited to 25.

**Abstract**
Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-μL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

**Objective**
We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

**Content**
Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   - Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   - Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   - Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   - Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   - Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   - Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   - Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   - Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small volume Molecular Detection
   - Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    - Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
    - Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

**Lecture notes**
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

**Literature**
There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

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**Autumn Semester 2022**

W 6 credits 3G A. de Mello

529-0837-01L Biomicrofluidic Engineering
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to 

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to

The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

The course offers an introduction into the structure and function of the human body, and how these are interlinked with one another.

636-0108-00L Biological Engineering and Biotechnology W 4 credits 3V M. Fussenegger

Abstract

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content


Lecture notes Handout during the course.

Biology Courses

Number Title Type ECTS Hours Lecturers

227-0399-10L Physiology and Anatomy for Biomedical Engineers I W 3 credits 2G M. Wyss

Abstract

This course offers an introduction into the structure and function of the human body, and how these are interlinked with one another. Focusing on physiology, the visualization of anatomy is supported by 3D-animation, Computed Tomography and Magnetic Resonance imaging.

Objective

To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

Content

- The Human Body: nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

Lecture notes Lecture notes and handouts

Literature

Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008
Faller A., Schuenke M. The Human Body; Thieme 2004
Netter F. Atlas of human anatomy; Elsevier 2014

227-0945-00L Cell and Molecular Biology for Engineers I W 3 credits 2G to be announced

Abstract

The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective

After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes Scripts of all lectures will be available.

Literature

## Taught competencies

### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

### Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

## Biological Methods for Engineers (Basic Lab) [227-0949-00L]

**Number of participants limited to 10.**

### Abstract
The course during 7 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

### Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

### Content
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

## Biomedical Imaging [227-0385-10L]

### Abstract
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

### Objective
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

### Content
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

## Biomedical Engineering [227-0386-00L]

### Abstract
Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

### Literature
- Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011
- Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

### Prerequisites / notice
- Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

## Bioimaging

### Track Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
</tr>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. Through practical computer and programming exercises, the students are given the opportunity to use deep learning, Convolutional Neural Networks, image segmentation, motion extraction and tracking, 3D data extraction, invariant features, specific object recognition and object class recognition. Deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

The course language is English.
Content

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes

Available online

Literature

Will be indicated during the lecture.

Recommended Elective Courses

These courses are particularly recommended for the Bioimaging track. Please consult your track advisor if you wish to select other subjects.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0311-00L</td>
<td>Qubits, Electrons, Photons</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>

Abstract

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

Content

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature


Supplementary material will be uploaded in Moodle.

- - - - - -

+ (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer

+ (as account of those formidable years) G. Gamow, "Thirty Years that Shook Physics", 1985, Dover Publications Inc.

Prerequisites / notice

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
Deep Learning in Artificial and Biological Neuronal Networks

Abstract

Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks is a legitimate approach to think differently about state-of-the-art ANN training methods.

Objective

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience.

These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes

The lecture slides will be provided as a PDF after each lecture.

Prerequisites / notice

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).

2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

227-0967-00L Computational Neuroimaging Clinic W 3 credits 2V K. Stephan

Prerequisite: Successful completion of course "Methods & Models for fMRI Data Analysis", "Translational Neuroimaging" or "Computational Psychiatry"

Abstract

This seminar teaches problem solving skills for computational neuroimaging, based on joint analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

Objective

1. Consolidation of theoretical knowledge (obtained in the following courses: 'Methods & models for fMRI data analysis', 'Translational Neuroimaging', 'Computational Psychiatry') in a practical setting.
2. Acquisition of practical problem solving strategies for computational modeling of neuroimaging data.

Content

This seminar teaches problem solving skills for computational neuroimaging, based on joint analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

Prerequisites / notice

The participants are expected to have successfully completed at least one of the following courses:
- 'Methods & models for fMRI data analysis',
- 'Translational Neuroimaging',
- 'Computational Psychiatry'

227-0969-00L Methods & Models for fMRI Data Analysis W 6 credits 4V K. Stephan
227-0971-00L Computational Psychiatry

This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

227-1033-00L Neuromorphic Engineering I

This course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Objective
This course aims at bridging the gap between mathematical modelers and clinical neuroscientists by teaching computational techniques in the context of clinical applications. The hope is that the acquisition of a joint language and tool-kit will enable more effective communication and joint translational research between fields that are usually worlds apart.

Content
This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/ for details.

227-1037-00L Introduction to Neuroinformatics

This course covers analog circuit examples with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools. Prerequisites: Background in basics of semiconductor physics helpful, but not required.

227-2037-00L Physical Modelling and Simulation

This course teaches fundamental methods in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active membranes of neurons provide theoretical background, but also demonstrates open source software in application to concrete examples.

Objective
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

Abstract
This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.
Objective

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiscale simulations through several practical examples of HP-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

151-0605-00L Nanosystems

Abstract

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.
Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.
Self-assembly and directed assembly of 2D and 3D structures.

Special emphasis is placed on the emerging field of molecular electronic devices.

Objective

Familiarize students with basic science and engineering principles governing the nano domain.

Content

The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale
Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.
Self-assembly and directed assembly of 2D and 3D structures.

Prerequisites / notice

Course format:
Lectures and Mini-Review presentations: Thursday 10-13

Homework: Mini-Review (compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

252-0543-01L Computer Graphics

Abstract

This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

Objective

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students’ curiosity to explore the field of computer graphics in subsequent courses or on their own.

Content

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

Lecture notes

no

Literature

Books:
High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
Multiple view geometry in computer vision
Physically Based Rendering: From Theory to Implementation

Prerequisites / notice

Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.

The programming assignments will be in C++. This will not be taught in the class.
### Objective

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biopsies.

### Literature

- Netter F. Atlas of human anatomy; Elsevier 2014
- Faller A., Schuenke M. The Human Body; Thieme 2004
- Focusing on physiology, the visualization of anatomy is supported by 3D-animation, Computed Tomography and Magnetic Resonance imaging.

### Pharmaceutical Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0976-00L</td>
<td>Computational Psychiatry &amp; Computational Psychosomatics</td>
<td>W</td>
<td>2 credits</td>
<td>4S</td>
<td>K. Stephan</td>
</tr>
</tbody>
</table>

### Prerequisites / notice

Participants are expected to be familiar with general principles of statistics (including Bayesian statistics) and have successfully completed the course “Computational Psychiatry” (Course number 227-0971-00L).
Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes
Scripts of all lectures will be available.

Literature

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
</tbody>
</table>

Prerequisites / notice
Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority.

Number of participants limited to 10.

Abstract
The course during 7 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Content
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Prerequisites / notice
Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority.

Taught competencies

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<td>Decision-making</td>
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</tr>
</tbody>
</table>

Biomedical Imaging

Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.
Objective
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

Content
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Prerequisites / notice
Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

227-0386-00L Biomedical Engineering W 4 credits 3G J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

Content
- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.

Lecture notes
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Taught competencies

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

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving not assessed
- Project Management not assessed

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

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

227-0447-00L Image Analysis and Computer Vision W 6 credits 3V+1U E. Konukoglu, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards personalized health.

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanismbiological function of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

The learning objectives include
1. advanced knowledge of the state-of-the-are in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Number of participants limited to 30

Material will be provided on Moodle and eColab.

Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

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4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
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7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

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5. improved programming skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Number of participants limited to 30

Material will be provided on Moodle and eColab.

Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.
### Trauma Biomechanics

**Abstract**

Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

**Objective**

Introduction to the basic principles of trauma biomechanics.

**Content**

This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

**Lecture notes**

Handouts will be made available.

**Literature**


**Taught competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Personal Competencies: Adaptability and Flexibility, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

**Recommended Elective Courses**

These courses are particularly recommended for the Biomechanics track. Please consult your track advisor if you wish to select other subjects.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0524-00L</td>
<td>Continuum Mechanics I</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>A. E. Ehret</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoelasticity, Examples of engineering applications, Comparison with experiments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>151-0601-00L</td>
<td>Theory of Robotics and Mechatronics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>to be announced</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degrees of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control. Robots is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degrees of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.</td>
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<tr>
<td>Objective</td>
<td>Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degrees of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.</td>
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<tr>
<td>Content</td>
<td>An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degrees of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.</td>
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<tr>
<td>Lecture notes</td>
<td>Available.</td>
<td></td>
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<tr>
<td>151-0604-00L</td>
<td>Microrobots</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<tr>
<td>Objective</td>
<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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<tr>
<td>Content</td>
<td>Main topics of the course include: - Scaling laws at micro/nano scales - Electromechanics - Low Reynolds number flows - Observation tools - Materials and fabrication methods - Applications of biomedical microrobots</td>
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<tr>
<td>Lecture notes</td>
<td>The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The lecture will be taught in English.</td>
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<tr>
<td>151-0605-00L</td>
<td>Nanosystems</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>A. Stemmer</td>
</tr>
</tbody>
</table>

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 362 of 2345
**Abstract**

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.

Special emphasis on the emerging field of molecular electronic devices.

**Objective**

Familiarize students with basic science and engineering principles governing the nano domain.

The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.

**Literature**


**Prerequisites / notice**

The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

**151-0905-00L Medical Technology Innovation - From Concept to Clinics**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
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<th>I. Herrmann</th>
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</thead>
</table>

**Abstract**

Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

**Literature**


**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td>Project Management</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
<td>assessed</td>
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<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<td></td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<td></td>
<td>Negotiation</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptable and Flexible</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

**263-5702-00L Seminar on Digital Humans**

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<tr>
<th>W</th>
<th>2 credits</th>
<th>2S</th>
<th>M. Gross, B. Solenthaler, S. Tang, R. Wampfler</th>
</tr>
</thead>
</table>

**Abstract**

This seminar covers advanced topic in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

**Objective**

The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills.
This seminar covers advanced topics in digital human images including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.

Individual research papers are selected each term. See https://vig.inf.ethz.ch/ and http://graphics.ethz.ch/ for example papers.

### Frontiers in Nanotechnology
**Objective**
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Content
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

### Wearable and Mobile Technologies of the Future - Focus on Sports and Health
**Abstract**
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

**Objective**
Objective 1: Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: Acquire skills to design novel non-invasive technologies for sport and health.

Content
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

### Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions
**Objective**
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
## Content

- Introduction, problem definition, overview
- Rehabilitation of visual function
  - Anatomy and physiology of the visual sense
  - Technical aids (glasses, sensor substitution)
  - Retina and cortex implants
  - Rehabilitation of hearing function
  - Anatomy and physiology of the auditory sense
  - Hearing aids
  - Cochlea Implants
  - Rehabilitation and use of kinesthetic and tactile function
  - Anatomy and physiology of the kinesthetic and tactile sense
  - Tactile/haptic displays for motion therapy (incl. electrical stimulation)
  - Role of displays in motor learning
  - Rehabilitation of vestibular function
  - Anatomy and physiology of the vestibular sense
  - Rehabilitation strategies and devices (e.g. BrainPort)
- Rehabilitation of vegetative functions
  - Cardiac Pacemaker
  - Phrenic stimulation, artificial breathing aids
  - Bladder stimulation, artificial sphincter
  - Brain stimulation and recording
- Brain stimulation and recording
  - Deep brain stimulation for patients with Parkinson, epilepsy, depression
  - Brain-Computer Interfaces

## Literature

### Introductory Books:

### Selected Journal Articles and Web Links:

### Prerequisites / notice

**Prerequisites:**
- Students of higher semesters and PhD students of D-MAVT, D-ITET, D-INFK, D-HEST

**Notice:**
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Abstract

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective

The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETH2/IBM Nanotcenter if needed.

Content

Mostly formal lectures (2 x 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

376-1351-00L Micro/Nanotechnology and Microfluidics for Biomedical Applications

Abstract

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disc technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

Lecture notes

Handouts are deposited online (moodle).

Literature


(available online via ETH library)

Handouts and references therin.

376-1720-00L Application of MATLAB in the Human Movement Sciences

Abstract

Students will learn to import, process and graphically present experimental data using the MATLAB computing environment. Both the data and the methods of analysis will be typical for experiments in Human Movement Science (i.e. kinematics, kinetics and electromyography).

Objective

Students will acquire the ability to independently load, plot, and process kinematic, kinetic and electromyographical data using the MATLAB computing environment.

Content

Drawbacks of Excel; Possibilities in MATLAB; Import of several data formats; Plot of one and more signals; Removing of an offset and filtering of data based on self-written functions; Normalisation and parametrisation of data; Reliability; Interpolation, Differentiation and Integration in MATLAB.

Literature

Handouts and references therin.

Prerequisites / notice

A Laptop with MATLAB installed (v2009 or higher) and wireless internet access is mandatory. Two students can share a laptop if necessary. A MATLAB student version can be obtained at Stud-IDES for free.

376-1794-00L Colloquium in Biomechanics

Abstract

Current topics in biomechanics presented by speakers from academia and industry.

Objective

Getting insight into actual areas and problems of biomechanics.

376-2017-00L Biomechanics of Sports Injuries and Rehabilitation

Abstract

This lectures introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

### Biology Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course offers an introduction into the structure and function of the human body, and how these are interlinked with one another. Focusing on physiology, the visualization of anatomy is supported by 3D-animation, Computed Tomography and Magnetic Resonance imaging.</td>
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<tr>
<td>Objective</td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
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<tr>
<td>Content</td>
<td>- The Human Body: nomenclature, orientations, tissues</td>
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<td></td>
<td>- Musculoskeletal system, Muscle contraction</td>
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<td></td>
<td>- Blood vessels, Heart, Circulation</td>
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<td></td>
<td>- Blood, Immune system</td>
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<td></td>
<td>- Respiratory system</td>
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<td></td>
<td>- Acid-Base-Homeostasis</td>
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<tr>
<td>Literature</td>
<td>Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008</td>
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<td></td>
<td>Faller A., Schuenke M. The Human Body; Thieme 2004</td>
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<td>Neter F. Atlas of human anatomy; Elsevier 2014</td>
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<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>to be announced</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.</td>
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<tr>
<td>Objective</td>
<td>After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.</td>
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</tbody>
</table>
Content
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes
Scripts of all lectures will be available.

Literature

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

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

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

Medical Physics

Track Core Courses
During the Master programme, a minimum of 12 CP must be obtained from track core courses.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
227-0311-00L | Qubits, Electrons, Photons | W | 6 credits | 3V+2U | T. Zambelli

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing).
Content

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature


Supplementary material will be uploaded in Moodle.

Prerequisites / notice

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies

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

Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

227-0385-10L Biomedical Imaging W 6 credits 5G S. Kozerke, K. P. Prüssmann

Abstract

Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

Objective

To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

Content

- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Lecture notes

Lecture notes and handouts

Literature

Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Prerequisites / notice

Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

227-0943-00L Radiobiology W 2 credits 2V M. Pruschy

Abstract

The purpose of this course is to impart basic knowledge in radiobiology in order to handle ionizing radiation and to provide a basis for predicting the radiation risk.

Prerequisites / notice

Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming
Objective
By the end of this course the participants will be able to:

a) interpret the 5 Rs of radiation oncology in the context of the hallmarks of cancer
b) understand factors which underpin the differing radiosensitivities of different tumors
c) follow rational strategies for combined treatment modalities of ionizing radiation with targeted agents
d) understand differences in the radiation response of normal tissue versus tumor tissue
e) understand different treatment responses of the tumor and the normal tissue to differential clinical-related parameters of radiotherapy (dose rate, LET etc.).

Content
Einführung in die Strahlenbiologie ionisierender Strahlen: Allgemeine Grundlagen und Begriffsbildungen; Mechanismen der biologischen Strahleneinwirkung: Strahleneinwirkung auf Zellen, Gewebe und Organe; Modifikation biologischer Strahleneinwirkung; Strahlentherapie: Chromosomenveränderungen, DNA-Defekte, Reparaturprozesse; Molekulare Strahlenbiologie: Bedeutung inter- und intrazellulärer Signalübertragungsprozesse, Apoptose, Zellzyklus-Checkpoints; Strahlenrisiko: Strahlenkrankheit, Krebsinduktion, Mutationsauslösung, pränatale Strahleneinwirkung; Strahlenbiologische Grundlagen des Strahlenschutzes; Nutzen-Risiko-Abwägungen bei der medizinischen Strahlenanwendung; Prädiktive strahlenbiologische Methoden zur Optimierung der therapeutischen Strahlenanwendung.

Lecture notes
Beilagen mit zusammenfassenden Texten, Tabellen, Bild- und Grafikdarstellungen werden abgegeben

Literature
Literaturliste wird abgegeben.

Prerequisites / notice

Basic Clinical Radiobiology, edited by Joiner, van der Kogel, 2018

Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

Relevant Elective Courses
These courses are particularly recommended for the Medical Physics track. Please consult your track advisor if you wish to select other subjects.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiologically and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.</td>
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<tr>
<td>Objective</td>
<td>Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.</td>
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</table>

Number | Title                                                   | Type | ECTS | Hours | Lecturers                  |
-------|---------------------------------------------------------|------|------|-------|----------------------------|
| 402-0674-00L | Physics in Medical Research: From Atoms to Cells | W    | 6    | 2V+1U | B. K. R. Müller            |
| Abstract   | Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epithelial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells. |      |      |       |                            |
| Objective  | The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour. As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced. The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes. High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering. Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. |      |      |       |                            |
| Content    | The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes. |      |      |       |                            |

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<th>Number</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>227-0941-00L</td>
<td>Physics and Mathematics of Radiotherapy Planning</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>(University of Zurich)</td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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</tbody>
</table>
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

Objective

The course will provide a detailed introduction to radiotherapy treatment planning. The course considers the physical interactions of radiation in tissue, the mathematical aspects of treatment planning and additional aspects of central importance for radiotherapy planning.

Content

Radiotherapy is one of the main treatment options against cancer. Today, more than 50% of cancer patients receive radiation as part of their treatment. Modern radiotherapy is a highly technology driven field.

Research and development in medical physics has improved the precision of radiotherapy substantially. Using intensity-modulated radiotherapy (IMRT), radiation can be delivered precisely to tumors while minimizing radiation exposure of healthy organs surrounding the tumor. Thereby, medical physics has provided radiation oncologists with new curative treatment approaches where previously only palliative treatments were possible. This lecture will provide a detailed introduction to radiotherapy treatment planning and will consists of three blocks:

1. The first part of the course considers the physical interactions of radiation in tissue. The physical interactions give rise to dose calculation algorithms, which are used to calculate the absorbed radiation dose based on a CT scan of the patient.

2. The second part considers the mathematical aspects of treatment planning. Mathematical optimization techniques are introduced, which are used in intensity-modulated radiotherapy to determine the external radiation fields that optimally irradiate the tumor while minimizing radiation dose to healthy organs.

3. The third part deals with additional aspects of central importance for radiotherapy planning. This includes biomedical imaging techniques for treatment planning and target delineation as well as image registration algorithms.

Lecture notes

The lectures are followed by computational exercises where students implement the main components of a radiotherapy treatment planning systems in two dimensions in Matlab.

Prerequisites / notice

Basic programming skills in Matlab (or willingness to learn) are needed for the exercises. Basic knowledge of calculus is needed, approximately corresponding to the 3rd year of a bachelor degree in physics, mathematics, computer science, engineering or comparable discipline.

Other Elective Courses

These courses may be suitable for the Medical Physics track. Please consult your track advisor.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6</td>
<td>3+1U</td>
<td>E. Konukoglu, F. Yu</td>
</tr>
</tbody>
</table>

Abstract


Objective

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>227-0965-00L</td>
<td>Micro and Nano-Tomography of Biological Tissues</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Stampanoni, F. Marone Welford</td>
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</table>

Abstract

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will cover a range of topics related to nanotechnology. It is designed for students with a background in engineering and aims to give an introduction into cellular and molecular biology, specifically for students interested in engineering. The focus is on understanding basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

### Cell and Molecular Biology for Engineers I

**Title**: Cell and Molecular Biology for Engineers I

*Does not take place this semester.*

**Abstract**: The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

**Objective**: After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

**Content**: Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytосkeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

**Lecture notes**: Scripts of all lectures will be available.


### Molecular Bioengineering

#### Track Core Courses

*During the Master programme, a minimum of 12 CP must be obtained from track core courses.*

### Biology Courses

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course offers an introduction into the structure and function of the human body, and how these are interlinked with one another. Focusing on physiology, the visualization of anatomy is supported by 3D-animation, Computed Tomography and Magnetic Resonance imaging.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>- The Human Body: nomenclature, orientations, tissues</td>
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<td></td>
<td>- Musculoskeletal system, Muscle contraction</td>
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<td>- Blood vessels, Heart, Circulation</td>
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<td>- Blood, Immune system</td>
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<td>- Respiratory system</td>
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<td>- Acid-Base-Homeostasis</td>
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<td><strong>Lecture notes</strong></td>
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<td>Lecture notes and handouts</td>
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<td><strong>Literature</strong></td>
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<td></td>
<td>Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008</td>
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<td></td>
<td>Faller A., Schuenke M. The Human Body; Thieme 2004</td>
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<td></td>
<td>Netter F. Atlas of human anatomy; Elsevier 2014</td>
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<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>to be announced</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.</td>
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<td></td>
<td>Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.</td>
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<td><strong>Literature</strong></td>
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</table>

### Medical Bioengineering

#### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies

- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Project Management: assessed
- Problem-solving: assessed

#### Social Competencies

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

#### Personal Competencies

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

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 372 of 2345
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biosystems. New phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges will be covered, focusing on critical research topics.

Objective

The objective of this course is to:

1. Introduce molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction to methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

- Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

- Design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

- Link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

- Handouts are deposited online (moodle).
- Literature:

Handouts and references therin.

4. Introduction to different material classes in use for medical applications.

Abstract

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Objective

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

- Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

- Design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

- Link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

- Handouts are deposited online (moodle).
- Literature:

Handouts and references therin.

402-0674-00L Physics in Medical Research: From Atoms to Cells

Abstract

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For high-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the more complex dynamical theory. Electron scattering is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Objective

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein adsorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced. The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the more complex dynamical theory. Electron scattering is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

R X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

465-0953-00L Biostatistics

Abstract

The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.

Objective

- know the commonly used methods in biostatistics
- perform simple data analysis with R
- perform complex data analysis with R

636-0108-00L Biological Engineering and Biotechnology

Abstract

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.
Lecturers
3V+2U
Hours

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
1. Insight Into The Mammalian Cell Cycle. Cycling, The Balance Between Proliferation and Cancer - Implications For Biopharmaceutical Manufacturing.
2. The Licence To Kill. Apoptosis Regulatory Networks - Engineering of Survival Pathways To Increase Robustness of Production Cell Lines.
5. From Target To Market. An Antibody's Journey From Cell Culture To The Clinics.
6. Biology and Malign Applications. Do Life Sciences Enable the Development of Biological Weapons?
7. Functional Food. Enjoy your Meal!

Lecture notes
Handout during the course.

►►► Recommended Elective Courses
These courses are particularly recommended for the Molecular Bioengineering track. Please consult your track advisor if you wish to select other subjects.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
<td></td>
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</tr>
</tbody>
</table>
| Content          | Main topics of the course include:  
- Scaling laws at micro/nano scales  
- Electrostatics  
- Electromagnetism  
- Low Reynolds number flows  
- Observation tools  
- Materials and fabrication methods  
- Applications of biomedical microrobots |
| Literature       | The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically. |
| Taught competencies | Subject-specific Competencies  
Concepts and Theories  
Techniques and Technologies |
|                  | Method-specific Competencies  
Analytical Competencies  
Decision-making  
Problem-solving  
Project Management  
Leadership and Responsibility  
Self-presentation and Social Influence  
Sensitivity to Diversity  
Negotiation |
|                  | Social Competencies  
Communication  
Cooperation and Teamwork  
Customer Orientation  
Leadership and Responsibility  
Self-presentation and Social Influence  
Sensitivity to Diversity  
Negotiation |
|                  | Personal Competencies  
Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  
Self-direction and Self-management |
| 151-0905-00L     | Medical Technology Innovation - From Concept to Clinics | W    | 4    | 3G    | I. Herrmann |
| Abstract         | Project-oriented learning on how to develop technological solutions to address unmet clinical needs. |
| Objective        | After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role. |
| Literature       | The lecture will be taught in English. |
| Taught competencies | Subject-specific Competencies  
Concepts and Theories  
Techniques and Technologies |
|                  | Method-specific Competencies  
Analytical Competencies  
Decision-making  
Problem-solving  
Project Management  
Leadership and Responsibility  
Self-presentation and Social Influence  
Sensitivity to Diversity  
Negotiation |
|                  | Social Competencies  
Communication  
Cooperation and Teamwork  
Customer Orientation  
Leadership and Responsibility  
Self-presentation and Social Influence  
Sensitivity to Diversity  
Negotiation |
|                  | Personal Competencies  
Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  
Self-direction and Self-management |
| 227-0311-00L     | Qubits, Electrons, Photons                         | W    | 6    | 3V+2U | T. Zambelli |
| Abstract         | In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis). |
| Objective        | Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics. Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition! In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems. IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!). |
Content
• Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
• Postulates of QM: Hilbert Spaces and Operators
• Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
• Density Operator
• Spin: Qubits, Bloch Equations, and NMR
• Entanglement
• Symmetries and Corresponding Operators
• Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
• Harmonic Oscillator: Creation and Annihilation Operators
• Identical Particles: Bosons and Fermions
• Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
• Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature

Supplementary material will be uploaded in Moodle.

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Taught competencies

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

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

<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Communication</th>
<th>not assessed</th>
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</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td></td>
<td>not assessed</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td></td>
<td>not assessed</td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td></td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td></td>
<td>not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td></td>
<td>assessed</td>
</tr>
</tbody>
</table>

| Negotiation | not assessed |

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td></td>
<td>assessed</td>
</tr>
</tbody>
</table>

Prerequisites / notice
Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

227-0385-10L Biomedical Imaging
W 6 credits 5G S. Kozerke, K. P. Prüssmann

Abstract
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

Objective
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

Content
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Prerequisites / notice
Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

227-0386-00L Biomedical Engineering
W 4 credits 3G J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.
Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content
History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.
Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND
moodle page of the course

Prerequisites / notice
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Taught competencies

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

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving not assessed
Project Management not assessed

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

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

227-0393-10L Bioelectronics and Biosensors W 6 credits 2V+2U J. Vörös, M. F. Yanik

Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nanometer scale.

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course will bring together engineering students from ETH Zurich and medical students from the University of Zurich to experience the rewards and challenges of such interdisciplinary work in a project based learning environment.

The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since such differences become the most evident during actual collaborative work, the course is based on a current project in physiology research that combines medicine and engineering. For the engineering students, the specific aims of the course are to:

- Acquire a working understanding of the anatomy and physiology of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the found solutions to a cross-disciplinary audience.

Prerequisites / notice

The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Lecture notes

Available online

Lecture notes

Will be indicated during the lecture.
Content
After a general introduction to interdisciplinary communication and detailed background on the collaborative project, the engineering students will team up with medical students to find solutions to a biomedical challenge. In the process, they will be supervised both by lecturers from ETH Zurich and the University of Zurich, receiving coaching customized to the project. The course will end with each team presenting their solution to a cross-disciplinary audience.

Lecture notes
Handouts and relevant literature will be provided.

Prerequisites / notice
IMPORTANT: Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.

Taught competencies
Method-specific Competencies
Analytical Competencies
assessed
Problem-solving
assessed
Project Management
assessed
Social Competencies
Communication
assessed
Cooperation and Teamwork
assessed
Customer Orientation
assessed

327-0505-00L Surfaces, Interfaces and their Applications I

Abstract
After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

Objective
To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

Content
Introduction to Surface Science
Physical Structure of Surfaces
Surface Forces (static and dynamic)
Adsorbates on Surfaces
Surface Thermodynamics and Kinetics
The Solid-Liquid Interface
Electron Spectroscopy
Vibrational Spectroscopy on Surfaces
Scanning Probe Microscopy
Introduction to Tribology
Introduction to Corrosion Science

Lecture notes
Script Download:
https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature
Script Download:
https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Prerequisites / notice
Chemistry:
General undergraduate chemistry
including basic chemical kinetics and thermodynamics

Physics:
General undergraduate physics
including basic theory of diffraction and basic knowledge of crystal structures

Taught competencies
Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
assessed
Method-specific Competencies
Analytical Competencies
assessed
Decision-making
assessed
Problem-solving
assessed
Personal Competencies
Creative Thinking
assessed
Critical Thinking
assessed

327-1101-00L Biomineralization

Abstract
The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

Objective
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

Content
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / sinterification in diatoms, radiolarians and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Lecture notes
Script with more than 600 pages with many illustrations will be distributed free of charge.

Literature
3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

Prerequisites / notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

376-1622-00L Practical Methods in Tissue Engineering

Data: 18.08.2022 12:39
Autumn Semester 2022
Abstract
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

Objective
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

402-0341-00L Medical Physics I

<table>
<thead>
<tr>
<th>Objective</th>
<th>Abstract</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>2V+1U</td>
<td>Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.</td>
<td>The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.</td>
</tr>
</tbody>
</table>

Lecture notes
A script will be provided.

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

<table>
<thead>
<tr>
<th>Objective</th>
<th>Abstract</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>3G</td>
<td>Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.</td>
<td>Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).</td>
</tr>
</tbody>
</table>

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Exercises are an integral part of the lecture.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
</tr>
</thead>
</table>

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

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

529-0240-00L Chemical Biology - Peptides

<table>
<thead>
<tr>
<th>Objective</th>
<th>Abstract</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>3G</td>
<td>An advanced course on the synthesis, properties and function of peptides in chemistry and biology.</td>
<td>Knowledge of the synthesis, properties and function of peptides in chemistry and biology. Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.</td>
</tr>
</tbody>
</table>

Lecture notes
Lecture notes will be made available online.

Literature
Citations from the original literature relevant to the individual lectures will be assigned weekly.


529-0615-00L Biochemical and Polymer Reaction Engineering

<table>
<thead>
<tr>
<th>Objective</th>
<th>Abstract</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>3G</td>
<td>Polymerization reactions and processes. Homogeneous and heterogeneous (emulsion) kinetics of free radical polymerization. Post treatment of polymer colloids. Bioprocesses for the production of molecules and therapeutic proteins. Kinetics and design of aggregation processes of macromolecules and proteins.</td>
<td>The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.</td>
</tr>
</tbody>
</table>

Prerequisites / notice
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.
Content

We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes, Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

Lecture notes

Scripts are available on the web page of the Arosio-group: http://www.ariosigroup.ethz.ch/education.html

Additional handout of slides will be provided during the lectures.

Literature

H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

535-0423-00L Drug Delivery and Drug Targeting W 2 credits 1.5V J.-C. Leroux

Abstract

The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective

The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes

Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature


Further references will be provided in the course.

Taught competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies

Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies

Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

536-0507-00L Synthetic Biology II W 8 credits 4A S. Panke, Y. Benenson, J. Stelling

Does not take place this semester.

Students in the MSc Biotechnology (Programme Regulations 2017) may select Synthetic Biology II instead of the Research Project 1.

Abstract

7 months biological design project, during which the students are required to give presentations on advanced topics in synthetic biology (specifically genetic circuit design) and then select their own biological system to design. The system is subsequently modeled, analyzed, and experimentally implemented. Results are presented at an international student competition at the MIT (Cambridge).

Objective

The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.

Content

Presentations on advanced synthetic biology topics (eg genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence (DNA synthesis external), implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (www.igem.org).

Lecture notes

Handouts during course

Prerequisites / notice

The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc.

This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April.

Please note that the number of ECTS credits and the actual work load are disconnected.

►►► Other Elective Courses

These courses may be suitable for the Molecular Bioengineering track. Please consult your track advisor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilofer, A. Vagstad</td>
</tr>
</tbody>
</table>

Abstract

Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective

This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Updated handouts will be provided during the class.

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

### Biology Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course offers an introduction into the structure and function of the human body, and how these are interlinked with one another. Focusing on physiology, the visualization of anatomy is supported by 3D-animation, Computed Tomography and Magnetic Resonance imaging.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
| Content | - The Human Body: nomenclature, orientations, tissues  
- Musculoskeletal system, Muscle contraction  
- Blood vessels, Heart, Circulation  
- Blood, Immune system  
- Respiratory system  
- Acid-Base-Homeostasis |
| Literature | Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008  
Faller A., Schuenke M. The Human Body; Thieme 2004  
Netter F. Atlas of human anatomy; Elsevier 2014 |
| Lecture notes | Lecture notes and handouts |

| 227-0945-00L | Cell and Molecular Biology for Engineers I | W    | 3 credits | to be announced |
| Abstract | The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology. |
| Objective | After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested. |
| Content | Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells. In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade. |

| 227-0949-00L | Biological Methods for Engineers (Basic Lab) | W    | 3 credits | 5P     | C. Frei   |
| Abstract | The course during 7 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory. |
| Objective | The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology. |
| Content | The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology. |
| Prerequisites / notice | Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority. |
Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Self-influence: not assessed
- Sensitivity to Diversity: not assessed

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

Projects and Laboratory Courses

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>U. Koch</td>
</tr>
<tr>
<td></td>
<td>Strongly recommended prerequisite for Semester Projects and Master Theses at D-ITET (MSc BME, MSc EEIT, MSc EST).</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>- Knowledge on structure and content of scientific texts and presentations - Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article - Discussion of the practice of proper citing and scientific integrity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, &quot;in this paper&quot; paragraph, scientific part, summary, equations, figures) * Topic 2: Structure of Scientific Presentations * Topic 3: Citation Rules and Citation Software * Topic 4: Guidelines for Scientific Integrity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>ETH &quot;Citation Etiquette&quot;, see <a href="https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html">https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html</a> ETH &quot;Scientific Integrity&quot;, see <a href="https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html">https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html</a></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.</td>
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</tbody>
</table>

Additional Projects and Laboratory Courses (ONLY for Progr. Reg. 2020)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1772-20L</td>
<td>Semester Project</td>
<td>O</td>
<td>12</td>
<td>20A</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Registration in mystudies required!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The semester project is designed to train the students in solving specific biomedical engineering problems. This project uses the technical and social skills acquired during the master's program. The semester project is advised by a professor.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>see above</td>
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</tr>
</tbody>
</table>

Internship in Industry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1750-00L</td>
<td>Internship in Industry</td>
<td>W</td>
<td>12</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td>Only for Biomedical Engineering MSc (Programme Regulations 2020).</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The main objective of the 12-week internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Objective</td>
<td>see above</td>
<td></td>
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</tr>
</tbody>
</table>

Research Project (long)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1760-00L</td>
<td>Research Project (long)</td>
<td>W</td>
<td>24</td>
<td>40A</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Only for Biomedical Engineering MSc (Programme Regulations 2020).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The aim of the long research project is to perform a larger (exploratory) scientific study or a larger development project in a team. The duration of this project is at least four months (full-time) and it is finished with a report and/or prototype.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>see above</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Master’s Thesis

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
227-1101-00L | How to Write Scientific Texts | E- | 0 credits | U. Koch

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, “in this paper” paragraph, scientific part, summary, equations, figures)
* Topic 2: Structure of Scientific Presentations
* Topic 3: Citation Rules and Citation Software
* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
ETH “Citation Etiquette”, see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html
ETH “Scientific Integrity”, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

Science in Perspective

Master’s Thesis

Admission only if all the following apply:
- a bachelor program successful completed;
- b. any additional requirements necessary to gain admission to the master program BME have been successfully completed;
- c. both the semester project and (if applicable) the internship successfully completed.

Registration in myStudies required!

Abstract
The masters program culminates in a six months research project which addresses a scientific research questions on one’s chosen area of specialization. The masters thesis is supervised by a program-affiliated faculty member and the topic must be approved by the track advisor.

Objective
see above

Recommended Course Types

Research Topics in Biomedical Engineering

Objective
Getting insight into actual areas and problems of Biomedical Engineering and Health Care.

Seminar on Biomedical Magnetic Resonance

Objective
Getting insight into advanced topics in magnetic resonance imaging

Biomedical Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
<td></td>
</tr>
</tbody>
</table>

Special students and auditors need special permission from the lecturers.
Biotechnology Master

Master Studies (Programme Regulations 2021)

Core Courses

Courses

Students need to acquire a total of 6 ECTS in lectures in this category.
The list of core courses is a closed list, no other course can be added to this category.

Students need to pass both lectures offered in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0101-00L</td>
<td>Systems Genomics</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>N. Beerenwinkel, C. Beisel, S. Reddy</td>
</tr>
</tbody>
</table>

Abstract
This lecture course is an introduction to Systems Genomics. It addresses how fundamental questions in biological systems are studied and how the resulting data is statistically analyzed in order to derive predictive mathematical models. The focus is on viewing biology from a genomic perspective, which requires high-throughput experimental methods (e.g., RNA-seq, genome-scale screening, single-cell sequencing, cellular genetic barcoding) that are used to obtain quantitative data in Systems Genomics. They will learn how to use these data to develop mathematical models and efficient statistical inference algorithms to recognize patterns, molecular interrelationships, and systems behavior. Finally, students will gain a perspective of how Systems Genomics can be used for applied biological sciences (e.g., drug discovery and screening, bio-production, cell line engineering, biomarker discovery, and diagnostics).

Objective
The goal of this course is to learn how a detailed quantitative description of genome biology can be employed for a better understanding of molecular and cellular processes and function. Students will learn fundamental questions driving the field of Systems Genomics. They will also be introduced to traditional and advanced state-of-the-art technologies (e.g., CRISPR-Cas9 screening, droplet-microfluidic sequencing, cellular genetic barcoding) that are used to obtain quantitative data in Systems Genomics. They will learn how to use these data to develop mathematical models and efficient statistical inference algorithms to recognize patterns, molecular interrelationships, and systems behavior. Finally, students will gain a perspective of how Systems Genomics can be used for applied biological sciences (e.g., drug discovery and screening, bio-production, cell line engineering, biomarker discovery, and diagnostics).

Content
Lectures in Systems Genomics will alternate between lectures on (i) biological questions, experimental technologies, and applications, and (ii) statistical data analysis and mathematical modeling. Selected complex biological systems and the respective experimental tools for a quantitative analysis will be presented. Some specific examples are the use of RNA-sequencing to do quantitative gene expression profiling, CRISPR-Cas9 genome scale screening to identify genes responsible for drug resistance, single-cell measurements to identify novel cellular phenotypes, and genetic barcoding of cells to dissect development and lineage differentiation.

Main Topics:
- Next-generation sequencing
- Transcriptomics
- Biological network analysis
- Functional and perturbation genomics
- Single-cell biology and analysis
- Genomic profiling of the immune system
- Genomic profiling of cancer
- Evolutionary genomics
- Genome-wide association studies

Selected genomics datasets will be analyzed by students in the tutorials using the statistical programming language R and dedicated Bioconductor packages.

Lecture notes
The PowerPoint presentations of the lectures as well as other course material relevant for an active participation will be made available online.

Literature

Research Project duration: 12 weeks, completed with a written report.

Research Project and Industry Internship

Students can choose between Research Project OR Industry Internship. Duration: 12 weeks full-time min.

Must be carried out in a different research group/company than the master’s thesis.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course provides an overview of modern concepts of bioengineering across different levels of complexity, from single molecules to systems, microscaled reactors to production environments, and across different fields of applications.

Objective
Students will be able to recognize major developments in bioengineering across different organisms and levels of complexity and be able to relate these to major technological and conceptual advances in the underlying sciences.

Content
Molecular and cellular engineering: Synthetic biology; Engineering strategies in biology; from single molecules to systems; downscaling bioengineering; Bioengineering in chemistry, pharmaceutical sciences, and diagnostics, personalized medicine.

Lecture notes
Handouts during class

Literature
Will be announced during the course

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Personal Competencies
Critical Thinking
assessed
assessed
assessed

Research Project duration: 12 weeks, completed with a written report.

Industry internship of at least 12 weeks, completed with a written report.
Objective
Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the courses.

Prerequisites / notice
The students look for a placement themselves.

Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0900-10L</td>
<td>Master’s Thesis&lt;br&gt;Only for Biotechnologie Master, Programme Regulations 2021.</td>
<td>O</td>
<td>44</td>
<td>91D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Students can only start with their master's thesis if:
a. The BSc programme has been completed successfully
b. Assigned additional requirements for the admission to the master's degree programme have been passed
c. At least 64 ECTS have been acquired for the master's degree programme, including 22 ECTS in the core course category and the 16 ECTS in the research projects and internships category

Abstract
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is carried out under the supervision of a professor in a research group of the D-BSSE, usually at the D-BSSE. Students are free to choose the area.

Objective
In the Master thesis students prove their ability to independent, structured and scientific working.

Core Courses

Students need to acquire a total of 8 ECTS in lectures in this category.
The list of core courses is a closed list, no other course can be added to this category.
Students need to pass both lectures offered in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0102-00L</td>
<td>Advanced Bioengineering&lt;br&gt;Only for Biotechnologie Master, Programme Regulations 2017.</td>
<td>O</td>
<td>4</td>
<td>3S</td>
<td>R. Platt, J. Stelling, B. Treutlein</td>
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</table>

Abstract
This course provides an overview of modern concepts of bioengineering across different levels of complexity, from single molecules to systems, microscaled reactors to production environments, and across different fields of applications.

Objective
Students will be able to recognize major developments in bioengineering across different organisms and levels of complexity and be able to relate it to major technological and conceptual advances in the underlying sciences.

Content
Molecular and cellular engineering; Synthetic biology; Engineering strategies in biology; from single molecules to systems; downscaling bioengineering; Bioengineering in chemistry, pharmaceutical sciences, and diagnostics, personalized medicine.

Techniques and Technologies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Competencies</th>
<th>Literature</th>
<th>Lecture notes</th>
<th>Taught competencies</th>
<th>Competencies</th>
<th>Literature</th>
<th>Lecture notes</th>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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Research Projects and Internship

Students need to acquire a total of 20 ECTS in this category.

Either choose Research Project I (8 ECTS) and Research Project II (12 ECTS)
Or choose Research Project I (8 ECTS) and Industry Internship (12 ECTS)
Instead of Research Project I (8 ECTS) students may also choose Synthetic Biology II (8 ECTS)

Research Projects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0802-00L</td>
<td>Research Project I&lt;br&gt;Only for Biotechnologie Master BSc, Programme Regulations 2017.</td>
<td>O</td>
<td>8</td>
<td>23A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.
Research Project I duration: 8 weeks

Objective
Students get acquainted with scientific working methods and deepen their knowledge in a particular research area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0803-00L</td>
<td>Research Project II&lt;br&gt;Only for Biotechnologie Master BSc, Programme Regulations 2017.</td>
<td>W</td>
<td>12</td>
<td>34A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.
Research Project II duration: 12 weeks

Objective
Students get acquainted with scientific working methods and deepen their knowledge in a particular research area.

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0507-00L</td>
<td>Synthetic Biology II&lt;br&gt;Does not take place this semester. Students in the MSc Biotechnology (Programme Regulations 2017) may select Synthetic Biology II instead of the Research Project I.</td>
<td>W</td>
<td>8</td>
<td>4A</td>
<td>S. Panke, J. Stelling</td>
</tr>
</tbody>
</table>

Abstract
7 months biological design project, during which the students are required to give presentations on advanced topics in synthetic biology (specifically genetic circuit design) and then select their own biological system to design. The system is subsequently modeled, analyzed, and experimentally implemented. Results are presented at an international student competition at the MIT (Cambridge).
The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.

Presentations on advanced synthetic biology topics (eg genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence, (DNA synthesis external) implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (www.igem.org).

The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc.

This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April.

Please note that the number of ECTS credits and the actual work load are disconnected.

### Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0804-00L</td>
<td>Industry Internship ■</td>
<td>W</td>
<td>12 credits</td>
<td>34A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

**Abstract**

Industry internship of at least 12 weeks, completed with a written report.

**Objective**

Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the courses.

**Prerequisites / notice**

The students look for a placement themselves.

### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0900-00L</td>
<td>Master's Thesis ■</td>
<td>O</td>
<td>40 credits</td>
<td>91D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is carried out under the supervision of a professor in a research group of the D-BSSE, usually at the D-BSSE. Students are free to choose the area.

**Objective**

In the Master Thesis students prove their ability to independent, structured and scientific working.

### Practical Training

**All listed lab courses are mandatory.**

**For Students in Biotechnology Master, Programme Regulation 2021: 16 ECTS in this category are mandatory.**

**For Students in Biotechnology Master, Programme Regulation 2017: 14 ECTS in this category are mandatory.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0201-00L</td>
<td>Lab Course: Methods in Cell Analysis and Laboratory Automation ■</td>
<td>O</td>
<td>3 credits</td>
<td>6P</td>
<td>T. Horn</td>
</tr>
</tbody>
</table>

**Abstract**

The lab course is open for MSc Biotechnology students only.

**Objective**

- to understand the technical and physical principles of light microscopes and flow cytometers
- to have hands-on experience in the use of these technologies to analyze/image real samples
- to be able to run a basic analysis of the data and images obtained with flow cytometers and microscopes
- to get introduced to liquid handling (pipetting) robotics and learn how to implement a basic workflow

**Content**

The practical course will have five units at 2 days each (total 10 days):

1. **Flow Cytometry:**
   - Introduction to Flow Cytometry
   - Practical demonstration on flow cytometry analyzers and flow cytometry cell sorters
   - Flow cytometry sample preparation
   - Learn how to use flow cytometry equipment to analyze and sort fluorescence-labeled cells
2. **Light microscopy**
   - Learn how to build a microscope and understand the underlying physical principles
   - Learn how to use a modern automated wide field fluorescence microscope
   - Use this microscope to automatically acquire images of a cell culture assay to analyze the dose-dependent effect of a drug treatment
3. **Image Analysis**
   - Introduction to the fundamentals of image analysis
   - Learn the basics of the image analysis software Fiji/ImageJ
   - Use Fiji/ImageJ to analyze the images acquired during the microscopy exercise
4. **Laboratory Automation**
   - Introduction to the basics of automated liquid handling/ lab robotics
   - See examples on using lab automation for plasmid library generation and cell cultivation
   - Learn how to program and execute a basic pipetting workflow including liquid handling and labware transfers on Tecan and Hamilton robotic systems
5. **Presentations**
   - Each student will be assigned to an individual topic of the course and will have to prepare a presentation on it.
   - Presentations and discussion in form of a Colloquium

**Lecture notes**

You will find further information on the practical course and the equipment at:

https://www.bsse.ethz.ch/scf
https://www.bsse.ethz.ch/laf

**Literature**

Microscopy: Murphy and Davidson, Fundamentals of Light Microscopy and Electronic Imaging, John Wiley & Sons, 2012

Flow Cytometry: Shapiro, Practical Flow Cytometry, John Wiley & Sons, 2005


636-0203-00L  Lab Course: Microsystems and Microfluidics in Biology

Prerequisites / notice: The lab course is open for MSc Biotechnology students only.

Abstract: This practical course is an introduction to microsystems technology and microfluidics for the life sciences. It includes basic concepts of microsystem design, fabrication, and assembly into an experimental setup. Biological applications include a variety of measurements of cellular and tissue signals and subsequent analysis.

Objective: The students are introduced to the basic principles of microsystems technology. They get acquainted with practical scientific work and learn the entire workflow of (a) understanding the theoretical concept, (b) planning the experiment, (c) engineering of the needed device, (d) execution of the experiment and data acquisition, (e) data evaluation and analysis, and (f) reporting and discussion of the results.

Content: The practical course will consist of a set of 4 experiments.

Lecture notes: Notes and guidelines will be provided at the beginning of the course.

Literature:

636-0204-00L  Lab Course: Microbial Biotechnology

Prerequisites / notice: The lab course is open for MSc Biotechnology students only.

Abstract: Students will learn the foundations of monoseptic working practice and create and screen microbial libraries for identification of strains expressing different fluorescent protein (XFP) levels.

Objective: Students will learn the foundations of monoseptic working practice and create and screen microbial libraries for identification of strains expressing different fluorescent protein (XFP) levels.

Content: The practical course will consist of a set of 4 experiments. For each experiment, the student will be required to:
- understand the theoretical concept behind the experiment
- plan the experiment
- engineer the devices
- execute the experiments and acquire data
- evaluate and analyze the data
- report and discuss the results
A good quality of the final report will be expected and be an important criterion.

Taught competencies:

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
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<td>Cooperation and Teamwork</td>
<td>Self-direction and Self-management</td>
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<td>assessed</td>
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636-0103-00L  Advanced Courses

Definitions:
- Practicals: The lab course is open for MSc Biotechnology students only.
- Advanced Courses: Students need to acquire a total of 24 ECTS in this category. The list of advanced courses is a closed list, no other course can be added to this category.

Advanced Courses

636-0103-00L  Biomechanical-Orientated

Number  Title  Type  ECTS  Hours  Lecturers
636-0103-00L  Biomechanical-Orientated

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0103-00L</td>
<td>Biomechanical-Orientated</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>A. Hierlemann</td>
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</tbody>
</table>

Abstract: Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based micro devices and -systems and all related microfabrication processes.

Objective: Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.
Introduction to microtechnology, semiconductors, and micro electro mechanical systems (MEMS)

- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode.
- Silicon processing and fabrication steps
  - Silicon crystal structure and manufacturing
  - Thermal oxidation
  - Doping via diffusion and ion implantation
  - Photolithography
  - Thin film deposition: dielectrics and metals
  - Wet etching & bulk micromachining
  - Dry etching & surface micromachining
  - Microtechnological processing and fabrication sequence
- Optional: Packaging

Lecture notes
Handouts will be given to students at lecture.

Literature

Prerequisites / notice
Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

The information on the web can be updated until the beginning of the semester.

636-0104-00L Biophysical Methods

Abstract
Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective
Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content
The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:
- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI imaging
- Scanning tunneling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations

Lecture notes
Hand out will be given to students at lecture.

Literature
- Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press

Prerequisites / notice
The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

636-0105-00L Introduction to Biological Computers

Abstract
Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanotechnology and synthetic biology.
Objective

The course has the following objectives:

* Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms
* Introduce basic theories of computation
* Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include
- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly

* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations

* Foster creativity, research and communication skills through semester-long “Design challenge” assignment in the broad field of biological computing and biological circuit engineering.
Lecture 1. Introduction: what is molecular computation (part I)?

* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines

1st hour

* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour

* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation

* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4: Classical DNA computing

* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly

* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes

* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits

* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I

* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II

* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I

* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II

* RNAi logic circuits
* RNAi-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits

* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics

* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
The goal of this course is that the participants gain an understanding of data mining problems and algorithms to solve these problems, in particular in biological and medical applications.

Major topics include I) Microbial physiology of microbes (prokaryotes and selected fungi), II) Applications of Microbial Biotechnology, III) Enzymes - advanced kinetics and engineering, IV) Principles of in vivo directed evolution, V) System approaches to cell engineering/metalloco engineering, and VI) Trends in Microbial Biotechnology. The course is a mix of lectures and different exercise formats.

Lecture notes: Handout during the course.

Lecture notes: Notes will be provided in the forms of handouts.

Taught competencies:

- Subject-specific Competencies: Concepts and Theories, assessed
- Methods-specific Competencies: Analytical Competencies, assessed
- Social Competencies: Communication, assessed
- Personal Competencies: Self-direction and Self-management, assessed

Prerequisites / notice: Basic knowledge of molecular biology is assumed.

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Biological Engineering and Biotechnology

Objective: The course will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content:

Lecture notes: Lecture notes will be available online.

Literature:

As a way of general introduction, the following two review papers could be useful:


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Biological Engineering and Biotechnology

Objective: The course will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content:

Lecture notes: Lecture notes will be available online.

Literature:

As a way of general introduction, the following two review papers could be useful:


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Data Mining

Abstract: Data Mining, the search for statistical dependencies in large databases, is of utmost important in modern society, in particular in biological and medical research. This course provides an introduction to the key problems, concepts, and algorithms in data mining, and the applications of data mining in computational biology.

Objective: The goal of this course is that the participants gain an understanding of data mining problems and algorithms to solve these problems, in particular in biological and medical applications.

Content:
1. Data Mining, the search for statistical dependencies in large databases, is of utmost important in modern society, in particular in biological and medical research. This course provides an introduction to the key problems, concepts, and algorithms in data mining, and the applications of data mining in computational biology.
2. Feature Selection
3. Classification
4. Clustering
5. Distance functions

Lecture notes: Material will be provided in form of slides.

Literature: Will be provided during the course.

Prerequisites / notice: Basic understanding of mathematics, as taught in basic mathematics courses at the Bachelor's level.

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Biomolecular Nanotechnology

Abstract: Biomolecular nanotechnology is a broad field that focuses on the study and science of biological materials including DNA, RNA and proteins at length scales below 10 nm. This is a broad overview of the topic with a focus on current research themes.

Objective: The objective is to familiarise the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.
Introduction to biomacromolecules; Measurement techniques for characterisation of biomacromolecules; Fundamentals of molecular recognition; Recombinant DNA: Protein engineering; Directed evolution; Protein folding; Polymers; Elastin-like polypeptides; Intelligent materials; Spatially localized hydrogels; Mechanical properties of proteins and macromolecules; Single-molecule force spectroscopy

Representative literature:
(1) Alberts, Molecular Biology (Ch.2 Cellular chemistry).
(2) Ratner, Biomaterials Science (Ch. 2.3, 2.4 Polymers & hydrogels).
(3) Walsh, Protein Biochemistry, (Ch. 2, Protein Structure).

636-0117-00L Mathematical Modelling for Bioengineering and Systems Biology

Abstract
Basic concepts and mathematical tools to explore biochemical reaction kinetics and biological network dynamics.

Objective
The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course covers basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

Content
Biological Reaction Modelling

636-0118-00L Introduction to Dynamical Systems with Applications

Abstract
Many physical systems are dynamic and are characterized by internal variables that change with time. Describing the quantitative and qualitative features of this change is the topic of dynamical systems theory. Dynamical systems arise naturally in virtually all scientific disciplines including physics, biology, chemistry and engineering. This course is a broad introduction to the topic dynamical s

Objective
The goal of this course is to introduce the student to dynamical systems and to develop a solid understanding of their fundamental properties. The theory will be developed systematically, focusing on analytical methods for low dimensional systems, geometric intuition, and application examples from biology. Computer simulations using matlab will be used to demonstrate various concepts

Content
A dynamical view of the world; the importance of nonlinearity; solutions of differential equations; solving equations on the computer; the phase plane; fixed points and stability; linear stability analysis; classifications of linear systems; Liapunov functions and nonlinear stability; cycles and oscillations; bifurcations and bifurcation diagrams. Many biological examples will be used through the course to demonstrate the concepts

Lecture notes
Will be provided as needed.

Literature

Prerequisites / notice
Prerequisites: Calculus; a first course in differential equations; basic linear algebra (eigenvalues and eigenvectors). Matlab programming.

636-0109-00L Stem Cells: Biology and Therapeutic Manipulation

Abstract
Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

Objective
Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

Content
We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

Taufed competencies

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

Method-specific Competencies
Analytical Competencies
Communication
Self-presentation and Social Influence
Critical Thinking
Integrity and Work Ethics
not assessed
not assessed
not assessed
not assessed

636-0123-00L Problem-Based Approach to Spatial Biology

Abstract
This course entails lectures in tissue physiology, spatial methodologies and grantsmanship. In the project part, small working groups will perform the entire scientific process around formulating a research proposal with the aid of tutors.

Does not take place this semester.
Objective
The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will obtain the necessary toolkits to independently identify open research problems in various areas of spatial biology, to address these problems with suitable experimental strategies, and to formulate their approach in a research proposal.

Content
We will use a problem-based approach to explore the way in which single cells collaborate within tissues to achieve their common functions. A thorough comprehension of these tissue components is crucial for advancing our knowledge of normal homeostasis and pathophysiology; disrupted cellular interactions can lead to decreased tissue function or even carcinogenesis.

The project work will be conducted in small groups in guidance of tutors. Each group will focus on a different topic in spatial biology and will review the corresponding literature. They will identify open problems of interest in this area and will summarize their findings in a short, written review. The students will then develop an appropriate experimental strategy to address a question of interest and write a research proposal that features their approach. The final stage of the project work enable the students to practice the presentation of their research proposals and critical evaluation.

Literature
Will be provided during the course.

Prerequisites / notice
This course requires independent group work.

专题

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0103-00L</td>
<td>Microtechnology</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>A. Hierlemann</td>
</tr>
</tbody>
</table>

Abstract
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and -systems and all related microfabrication processes.

Objective
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.

Content
Introduction to microtechnology, semiconductors, and micro electro mechanical systems (MEMS)

- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode.
- Silicon processing and fabrication steps
  - Silicon crystal structure and manufacturing
  - Thermal oxidation
  - Doping via diffusion and ion implantation
  - Photolithography
  - Thin film deposition: dielectrics and metals
  - Wet etching & bulk micromachining
  - Dry etching & surface micromachining
  - Microtechnological processing and fabrication sequence
  - Optional: Packaging

Lecture notes
Handouts in English

Literature

Prerequisites / notice
Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitiorium of fundamental physics and quantum theory at the semester beginning can be offered.

The information on the web can be updated until the beginning of the semester.

Taught competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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636-0104-00L | Biophysical Methods | W | 4 credits | 3G | D. J. Müller |

Abstract
Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective
Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content
The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology, and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capacities and aptitude.

The biophysical methods to be taught will include:

- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI Imaging
- Scanning tunnelling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations
Lecture notes: Hand out will be given to students at lecture.

Literature:
- Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press

Prerequisites / notice: The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

<table>
<thead>
<tr>
<th>636-0105-00L</th>
<th>Introduction to Biological Computers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W 4 credits 3G Y. Benenson</td>
</tr>
</tbody>
</table>

Abstract: Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanothechnology and synthetic biology.

Objective:
- Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms
- Introduce basic theories of computation
- Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include
- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly

* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations
* Foster creativity, research and communication skills through semester-long "Design challenge" assignment in the broad field of biological computing and biological circuit engineering.
Content

Lecture 1. Introduction: what is molecular computation (part I)?
* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines
1st hour
* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour
* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation
* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4. Classical DNA computing
* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly
* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes
* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits
* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I
* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II
* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I
* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II
* RNAi logic circuits
* RNAi-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits
* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics
* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
The goal of this course is to introduce the student to dynamical systems and to develop a solid understanding of their fundamental properties. The theory will be developed systematically, focusing on analytical methods for low dimensional systems, geometric intuition, and biological applications.

### 636-0108-00L

**Abstract**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**

### 636-0018-00L

**Abstract**
Basic knowledge of molecular biology is assumed.

**Objective**
Basic concepts and mathematical tools to explore biochemical reaction kinetics and biological network dynamics. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

**Content**
Tentative list of topics:
1. Distance functions
2. Classification
3. Clustering
4. Feature Selection

### 636-0017-00L

**Abstract**
Mathematical Modelling for Bioengineering and Systems Biology

**Objective**
The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course covers basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

**Content**
Biological Reaction Modelling

### 636-0118-00L

**Abstract**
Introduction to Dynamical Systems with Applications to Biology

**Objective**
The goal of this course is to introduce the student to dynamical systems and to develop a solid understanding of their fundamental properties. The theory will be developed systematically, focusing on analytical methods for low dimensional systems, geometric intuition, and application examples from biology. Computer simulations using matlab will be used to demonstrate various concepts

**Content**
A dynamical view of the world; the importance of nonlinearity; solutions of differential equations; solving equations on the computer; the phase plane; fixed points and stability; linear stability analysis; classifications of linear systems; Liapunov functions and nonlinear stability; cycles and oscillations; bifurcations and bifurcation diagrams. Many biological examples will be used through the course to demonstrate the concepts

### Literature

Benenson, Y. Biocomputers: from test tubes to live cells. Molecular Biosystems 2009, 5:675:685


Basic knowledge of molecular biology is assumed.
Biology is becoming increasingly quantitative and mathematical modeling is now an integral part of biological research. In many biological phenomena, randomness plays an important role that can only be understood using stochastic models. This course will provide the students with a theoretical foundation for developing such stochastic models and analyzing processes, ranging from gene-expression to evolution.

### Abstract
Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

### Content
We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

### Taught competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Communication
- Social Competencies
  - Self-presentation and Social Influence
- Personal Competencies
  - Critical Thinking
  - Integrity and Work Ethics

### Electives
The electives list in the ETH course catalogue is an open list, and the courses listed in the ETH course catalogue provide just examples for possible elective courses, e.g. a selection of eligible courses. Students are expected to look for relevant courses in the ETH and University of Basel course catalogue and ask their mentor for approval. Courses from the advanced course category may also be taken as electives.

We particularly recommend browsing the University of Basel course catalogue for elective courses of relevant master's degree programs (using the filter "programme structure" on the course catalogue website), such as for example: Biomedical Engineering, Chemistry, Drug Sciences, Epidemiology, Infection Biology, Molecular Biology, Nanosciences.

### Literature

### Prerequisites / notice
Prerequisites: Calculus; a first course in differential equations; basic linear algebra (eigenvectors and eigenvalues). Matlab programming.

### Events
- **636-0109-00L** Stem Cells: Biology and Therapeutic Manipulation
  - **Objective**: Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.
  - **Abstract**: Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.
  - **Content**: We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.
  - **Topics will include**:
    - Embryonic and adult stem cells and their niches
    - Induced stem cells by directed reprogramming
    - Relevant basic cell biology and developmental biology
    - Relevant molecular biology
    - Cell culture systems
    - Cell fates and their molecular control by transcription factors and signalling pathways
    - Cell reprogramming
    - Disease modelling
    - Tissue engineering
    - Bioimaging, Bioinformatics
    - Single cell technologies
  - **Taught competencies**
    - Subject-specific Competencies
      - Concepts and Theories
      - Techniques and Technologies
    - Method-specific Competencies
      - Analytical Competencies
      - Communication
    - Social Competencies
      - Self-presentation and Social Influence
    - Personal Competencies
      - Critical Thinking
      - Integrity and Work Ethics
  - **Number**: 636-0109-00L
  - **Title**: Stem Cells: Biology and Therapeutic Manipulation
  - **Type**: W
  - **ECTS**: 4
  - **Hours**: 3G
  - **Lecturers**: T. Schroeder

- **636-0123-00L** Problem-Based Approach to Spatial Biology
  - **Objective**: The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will obtain the necessary toolkits to independently identify open research problems in various areas of spatial biology; to address these problems with suitable experimental strategies, and to formulate their approach in a research proposal.
  - **Content**: We will use a problem-based approach to explore the way in which single cells collaborate within tissues to achieve their common functions. A thorough comprehension of these tissue components is crucial for advancing our knowledge of normal homeostasis and pathophysiology; disrupted cellular interactions can lead to decreased tissue function or even carcinogenesis.
  - **Abstract**: This course entails lectures in tissue physiology, spatial methodologies and grantsmanship. In the project part, small working groups will perform the entire scientific process around formulating a research proposal with the aid of tutors.
  - **Literature**: Will be provided during the course.
  - **Prerequisites / notice**: This course requires independent group work.
  - **Number**: 636-0123-00L
  - **Title**: Problem-Based Approach to Spatial Biology
  - **Type**: W
  - **ECTS**: 4
  - **Hours**: 3G
  - **Lecturers**: A. Moor

- **636-0015-00L** An Introduction to Probability Theory and Stochastic Processes with Applications to Biology
  - **Abstract**: Biology is becoming increasingly quantitative and mathematical modeling is now an integral part of biological research. In many biological processes, ranging from gene-expression to evolution, randomness plays an important role that can only be understood using stochastic models. This course will provide the students with a theoretical foundation for developing such stochastic models and analyzing
  - **Objective**: The aim of this course is to introduce certain topics in Probability Theory and Stochastic Processes that have been specifically selected with an eye on biological applications. This course will teach students the tools and techniques for modeling and analyzing random phenomena. Throughout the course, several biological applications will be discussed and students will be encouraged to do additional reading based on their research interests.
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on using computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced. Computational algorithms providing insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises. Attendees will apply these concepts to a number of applications yielding biological insight into:

- maximum likelihood and Bayesian statistics
- phylogenetic & phylodynamic inference
- stochastic models in molecular evolution
- pathogen evolution
- macrolevolution of species
- epidemiology

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylogenetics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

## Literature


## Prerequisites / notice

The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.
Objective

Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Content

1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Lecture notes

All lecture material will be made available online via Moodle.

Literature

The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:

Murray, Mathematical Biology, Springer
Forgacs and Newman, Biological Physics of the Developing Embryo, CUP
Keener and Sneyd, Mathematical Physiology, Springer
Fall et al, Computational Cell Biology, Springer
Szallasi et al, System Modeling in Cellular Biology, MIT Press
Wolkenhauer, Systems Biology

Prerequisites / notice

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

636-0119-00L Introduction to Statistics and R

Objective

This course offers a practical introduction to the fundamentals of data analysis and R programming.

Content

Data analysis is fundamental for arriving at scientific conclusions and testing different hypotheses. This course offers a hands-on introduction to statistical analyses including: exploratory data analysis, testing differences in populations, p-values, power calculations, multiple testing, confounding, linear regression, maximum likelihood, model selection, and logistic regression; along with the fundamentals of R programming including markdown and data handling with the tidyverse.

Lecture notes

Lecture slides will be available

Prerequisites / notice

Access to Rstudio with some markdown and tidyverse packages installed.

636-0120-00L Introduction to Programming

Objective

This is a voluntary programming course BEFORE the start of the semester (September 2022). It is addressed primarily at students of the MSc Biotechnology (and MSc CBB). Other students may send a request to participate to: student-admin@bsse.ethz.ch

Abstract

Introduction to Programming provides an overview of the basic programming blocks needed to translate a problem, stated in textual form, into an algorithm that solves such problem. The course provides an introduction to the MATLAB programming language and covers Bash scripting and other programming languages such as R and Python.

Objective

The goal of this course is to give students, who have no prior programming background, a solid introduction to algorithm development and its successive implementation in a programming language. For students with previously acquired programming skills, the course will serve as a reinforcement of key aspects of structured programming in addition to providing a well-rounded introduction to MATLAB, R and Python.

Content

The course is structured in four main pillars:

• Logical thinking: Translating a problem into a conceptual sequence of computational steps. For example: [Problem] What is the GC content of a given DNA string? [Logical steps] i) Iterate through all nucleotides in the DNA string, one by one ii) Count the Cs or Gs iii) Divide the count of Cs or Gs by the length of the DNA string iv) Report the result.
• Writing code: Full introduction to the MATLAB programming languages (R and Python will also be covered). Solutions to all exercises will be provided in MATLAB, R and Python. Creation of programming projects with an integrated development environment (IDE).
• Primer of Unix commands: Command-line examples on how to access servers and computing resources at the D-BSSE. Submission of jobs to the EULER cluster.

Lecture notes

Available on course website (Moodle)

Literature

Publicly available material (links will be posted on the course website)

636-0552-00L Metals in Biology

Abstract

Analysis of key metalloenzymes including: Hydrolyases, Oxygenases, Oxidases, Hydrogenases, Nitrogenase, Redox-proteins, Oxygen evolving complex, Photosystem II, Metal trafficking in cells, Metal homeostasis, DNA-binding proteins, Biomimetic chemistry, Artificial Metalloenzymes etc.

Lecture notes

none

Literature

Publicly available material (links will be posted on the course website)
### Objective
Identify key features of metalloenzymes and enzyme mimics  
Deduce and draw reasonable reaction mechanisms catalyzed by metalloenzymes  
Understand the role of metalloenzymes in solving energy-related grand challenges  
Design functional enzyme mimics  
Critically analyze the structure and function of metalloproteins

### Chemical Biology

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<th>Exam Type</th>
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<tr>
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<td>Chemical Biology</td>
<td>W</td>
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<tr>
<td></td>
<td>The modern tools of chemical biology will be discussed and contextualized with a discussion of practical applications with those tools.</td>
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### Supramolecular Chemistry

<table>
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<tr>
<td>636-0551-00L</td>
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<td>This course provides an introduction to supramolecular chemistry. Prior knowledge in supramolecular chemistry is not a prerequisite for this course.</td>
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</table>

### Abstract
After this course, the student is expected to understand and be able to apply the basics of supramolecular chemistry: host-guest interactions, host design, self-assembly and simple enzyme mimetics.

### Content
This course provides an introduction to supramolecular chemistry. Prior knowledge in supramolecular chemistry is not a prerequisite for this course. We will first cover the basic concepts of supramolecular chemistry: non-covalent interactions, host-guest chemistry, binding constant determination and binding strength. Subsequently, we will take a closer look at how to bind different species: cations, anions and neutral organic molecules. Towards the end of the semester, we will cover self-assembly processes and applications of supramolecular structures as simple enzyme mimetics.

### Lecture notes
The lecture slides are provided online via ADAM. No additional literature is required. If additional information is desired, the book “Supramolecular Chemistry” by Jonathan W. Steed and Jerry L. Atwood (John Wiley & Sons) is recommended.

### Science in Perspective

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-BSSE
- see Science in Perspective: Language Courses ETH/UZH

### Biotechnology Master - Key for Type

<table>
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<tr>
<td>O</td>
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<td>W+</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

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<tr>
<td>V</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>072-0101-00L</td>
<td>Module 1: Foundations of Digitalisation</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Key terms: Digital transformation is more than digitisation of existing processes and information</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Independently of the building industry, Module 1 initially provides information about the characteristics of digitalisation through its principles and rules, enabling the participants to independently recognise the short-term and long-term changes that are resulting from it.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The first module addresses the topic of digitalisation and digital transformation in a holistic sense. It is much more than converting documents into PDFs or using software. It is about transforming processes, resources and information into a consistent and efficient digital system to make life easier for employees and customers. This journey always involves change. From the perspective of other industries, we first build up a basic understanding and discuss the opportunities and risks.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
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<td>072-0102-00L</td>
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<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Key terms: &quot;Behaviour for Collaboration&quot; - Structural questions on collaboration and the patterns of behaviour.</td>
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<td><strong>Objective</strong></td>
<td>In Module 2, we break from the theoretical idea of a purely technology-based, better collaboration and look at the situation realistically in order to be able to understand and develop new solutions and requirements.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The usual approach towards digital transformation is to train people to use new technologies. In contrary, we ask for the specific challenges and problems people have with change. We learn to understand viewpoints of different partners within building projects and new solutions to specific problems.</td>
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<td>072-0103-00L</td>
<td>Module 3: Foundation of Automation</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Key terms: Managed data, semantics and file formats</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Module 3 we leave behind the negative images from the early days of automation. A gloomy and misanthropic image of automation - both a bliss and a curse. We get to know the positive sides and learn to apply them. How do we become a sustainable &quot;Formula 1&quot;?</td>
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<tr>
<td><strong>Content</strong></td>
<td>What does it take to be able to work together in a digitally networked environment? How many &quot;techie genes&quot; are needed to work efficiently and effectively with structured data? The third module gives an insight into the principles of data architectures, data formats, attributes and platform technology. Machine readiness as an important requirement but also as a clear challenge e.g. to security requirements.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>The module offers the opportunity to prepare for the voluntary buildingSMART Professional Certification.</td>
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<td>072-0104-00L</td>
<td>Module 4: Foundation of Value Creation</td>
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<td><strong>Abstract</strong></td>
<td>Key terms: Added value of digital transformation, distributed data management, digital twin, logistics and robotics.</td>
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<td><strong>Objective</strong></td>
<td>Using specific examples, Module 4 illustrates the foundations and versatility of building information modeling (BIM), enabling participants to deal with the concepts, applications and mechanisms involved.</td>
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<td><strong>Content</strong></td>
<td>&quot;Highway to hell or highway to haven&quot; - the question of a clear and simple roadmap is always at the heart of a digital transformation. &quot;Value creation&quot; is a central goal. Digitalisation is often seen as a strategy from the productivity gap. The fourth module shows how strategic goals can be developed in a roadmap and implemented in practice and how the individual shareholders and stakeholders participate.</td>
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<td>072-0105-00L</td>
<td>Module 5: New Business Modelle</td>
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<td><strong>Abstract</strong></td>
<td>Key terms: Business models, cultural change, disruption, evolution, lean methods</td>
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<td><strong>Objective</strong></td>
<td>Module 5 focuses on cultural change, innovation, disruption or evolution? In this last module, we learn to question and discover what the 17 Sustainable Goals mean for our industry.</td>
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<td><strong>Content</strong></td>
<td>As a final module, new business models are discussed and explored. Examples will be used to explore patterns and interfaces and to analyse what is needed today and in the future for a successful and sustainable development of the sector. How can innovative ideas move us forward? What can we learn from design thinking? Why is it important for people to have useful and understandable measurable values? How do the 17 Sustainable Goals influence our industry?</td>
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#### Term Paper

The Term Paper is offered in spring semesters only.
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<tr>
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<td>O</td>
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**Key for Hours**

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<td>colloquium</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# CAS ARC in Project Leadership

## Core Courses

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<tr>
<th>Number</th>
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<td>Module 1: Understanding of Roles</td>
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<td>A. Paulus, S. Menz</td>
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<td>- Profession</td>
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<td>- Ethos and ethic</td>
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<td>- Organisational forms</td>
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<td>- Role and tasks</td>
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<td>- Attitude and practice</td>
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<tr>
<td>072-0202-00L</td>
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<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<td></td>
<td>- Organisation charts</td>
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<td>- Project knowledge and process understanding</td>
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<td>- Structure of the project</td>
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<td>- Agile project management</td>
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<td>- Socio-economic viewpoint</td>
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<td>- Perception of demand</td>
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<td>- Due diligence and duty of loyalty</td>
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<td>- Duties and tasks, liability</td>
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<td>- Using packages</td>
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<td></td>
<td>- Management and coordination</td>
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<td>Module 4: Guiding/Steering/Leading</td>
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<td>- Management and administration</td>
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<td>- Leadership</td>
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<td>- Team performance</td>
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<td>- Motivation and conflict resolution</td>
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<tr>
<td></td>
<td>- Management of unknowns</td>
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<td>- Decision making</td>
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<td>- Future perspectives</td>
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<td>- Micro and macro environment</td>
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► Term Paper

Offered in the Spring Semester.
### CAS ARC in Project Leadership - Key for Type

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<td>O</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Eligible for credits and recommended</td>
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<td>exercise</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# CAS ARC in Real Estate Strategies urban-peri-urban

## Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>072-0301-00L</td>
<td>Module 1: Perception of Demand</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>S. Menz</td>
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<td></td>
<td>Does not take place this semester.</td>
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<td></td>
<td>peri-urban and MAS in Architecture, Real Estate,</td>
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<td>Construction.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>Key words: construction and real estate market, micro and macro environment</td>
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<tr>
<td></td>
<td>Objective</td>
<td>In Module 1, by interpreting the snapshot of one’s own enterprise and opportunities and dangers to appreciate.</td>
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<td>Content</td>
<td>Introductory module «Enterprise» considers the role of organizations in the economic network of markets and their identity. It presents the peculiarities of planning offices as a service provider, shows different types of companies and discusses the business cycle from founding to succession planning. In addition, the branch-specific development of leadership and organizational models as well as the problem of access to international markets are examined. Accompanying the basics of a general business model for service companies are taught and key criteria defined.</td>
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<td></td>
<td>Literature</td>
<td>Literature recommendations at <a href="http://www.bauprozess.arch.ethz.ch">www.bauprozess.arch.ethz.ch</a> and <a href="http://www.kompetenz.arch.ethz.ch">www.kompetenz.arch.ethz.ch</a></td>
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<td>072-0302-00L</td>
<td>Module 2: State of the Art</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>Key words: Bauwerk Schweiz, new construction and renovation, economy</td>
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<td></td>
<td>Objective</td>
<td>Knowledge about type, extent and change of the building Switzerland and the main questions.</td>
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<td>Content</td>
<td>With more than CHF 3.585 billion (excluding land), Switzerland is the largest national capital. It grows by around 4.7 per cent each year, but its value is under-invested. Is there a risk of slippage? Should more be invested in maintenance / repair or more canceled and replaced? How big is the compaction potential in the stock? Excursus on civil engineering and infrastructure construction</td>
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<td>072-0303-00L</td>
<td>Module 3: Economic Interest</td>
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<td>1</td>
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<td>S. Menz</td>
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<tr>
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<td>Abstract</td>
<td>Key words: intention development, realization operation</td>
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<td></td>
<td>Objective</td>
<td>The participants understand a property in the context of a life cycle</td>
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<td>Content</td>
<td>The importance of a life-cycle-oriented approach has arrived in the Swiss construction and real estate sector. Cumulative management costs can exceed the cost of construction after just a few years. In this module, a systematic consideration of the phases and processes in the life cycle of a property takes place. Study I explores various aspects of life-cycle planning and construction.</td>
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<td>072-0304-00L</td>
<td>Module 4: Course of Action</td>
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<td></td>
<td>Abstract</td>
<td>Key words: maintenance, change, replacement</td>
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<tr>
<td></td>
<td>Objective</td>
<td>Preservation of value, increase in value, destruction of value and replacement construction</td>
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<td></td>
<td>Content</td>
<td>The various depths of intervention in dealing with a existing property and their effects are known.</td>
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<td>072-0305-00L</td>
<td>Module 5: Life Cycle and Resources</td>
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<td>2G</td>
<td>S. Menz</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>Key words: building fabric, material cycle</td>
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<tr>
<td></td>
<td>Objective</td>
<td>Production and disposal / reusability of building fabric, energy flows, pollutants</td>
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<td></td>
<td>Content</td>
<td>Building and breaking off is understood as an energy and material flow.</td>
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<td></td>
<td>Lecture notes</td>
<td>The total weight of all properties in Switzerland is estimated at around 1 billion tonnes. Every year around 10 million m3 of buildings are demolished and more than 60 million t of raw materials are used in new buildings. This module examines the cycle principle and its implications for selective decommissioning, disposal, landfiling, recycling and reuse, as well as the importance of the gray matter energy of materials.</td>
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<td></td>
<td>Literature</td>
<td>Continuation, reuse, demolition / new construction - stakeholders, goals and conflicting goals</td>
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## Term Paper

The term paper is offered in spring semester only.
<table>
<thead>
<tr>
<th>CAS ARC in Real Estate Strategies urban-peri-urban - Key for Type</th>
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<tbody>
<tr>
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<tr>
<td><strong>W+</strong></td>
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<tr>
<td><strong>W</strong></td>
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<td><strong>E-</strong></td>
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<tr>
<td><strong>Z</strong></td>
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### Key for Hours

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<td>lecture</td>
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<tr>
<td><strong>G</strong></td>
<td>lecture with exercise</td>
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<tr>
<td><strong>U</strong></td>
<td>exercise</td>
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<tr>
<td><strong>S</strong></td>
<td>seminar</td>
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<tr>
<td><strong>K</strong></td>
<td>colloquium</td>
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<tr>
<td><strong>P</strong></td>
<td>practical/laboratory course</td>
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<tr>
<td><strong>A</strong></td>
<td>independent project</td>
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<td><strong>D</strong></td>
<td>diploma thesis</td>
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<tr>
<td><strong>R</strong></td>
<td>revision course / private study</td>
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</table>

### ECTS

- European Credit Transfer and Accumulation System

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### Core Courses

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<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>072-0401-00L</td>
<td>Module 1: Market</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td></td>
<td>Only for CAS ARC in Unternehmensführung and MAS in Architecture, Real Estate, Construction.</td>
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<tr>
<td>Abstract</td>
<td>Key terms: Market, purpose and business model</td>
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<tr>
<td>Objective</td>
<td>The aim is to use a snapshot in time to interpret one’s own company and become able to assess opportunities and risks.</td>
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<tr>
<td>Content</td>
<td>The &quot;company&quot; module considers the role of organisations within the economic network of the markets and the nature of their identity. It presents the special aspects of planning offices as service providers, illustrates various types of company, and discusses companies’ life-cycle as they move from their founding to the period of planning for the succession. Both sector-specific development of management and organizational models and also the problems of obtaining access to international markets are also investigated. Alongside this, the foundations of a generally valid business model for service companies are described and key criteria are defined.</td>
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<td>Module 2: Acquisition</td>
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<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td>Abstract</td>
<td>Key terms: Competence, communication and network</td>
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<tr>
<td>Objective</td>
<td>The aim is to become able to analyse and implement the processes and instruments used for acquisition in one’s own company.</td>
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<td>Content</td>
<td>Acquisition represents a separate project in entrepreneurial activity, since all the activities involved in obtaining a commission fall under this term. The &quot;acquisition&quot; module focuses on imparting basic knowledge of networking and professional dialogue. Both of these tools require an assessment of one’s own situation with regard to competence, resources and customer relations. The conversation is a direct interaction: everyone involved is both an addressee and also basically an equal interlocutor. Networking can be learned: situational &quot;small talk,&quot; social competence and a healthy ability to communicate can be learned.</td>
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<td>Module 3: Marketing</td>
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<td>A. Paulus, S. Menz</td>
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<tr>
<td>Abstract</td>
<td>Key terms: Planning, positioning and identity</td>
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<td>Objective</td>
<td>The aim is to become familiar with the tools used in marketing and able to use them in specific situations.</td>
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<td>Content</td>
<td>Marketing means orienting company activities towards market demands. Communication between suppliers, clients and the competition plays the decisive role here. The “marketing” module illustrates the foundations of marketing planning for architects and engineers. The essential definitions are provided and the core tasks involved in marketing are described. On this basis, the way in which a marketing plan is developed is explained and strategic and operational marketing planning is described in detail. The topics of branding and the opportunities represented by press and public relations work for architects and planners round out the “marketing” module.</td>
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<td>Module 4: Financial Management</td>
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<tr>
<td>Abstract</td>
<td>Key terms: Cost accounting, budgeting and controlling</td>
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<tr>
<td>Objective</td>
<td>The aim is to become able to analyse one’s own company’s financial resources in detail, interpret key parameters for the current situation and act on them.</td>
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<td>Content</td>
<td>Financial management means achieving the target company output with costs that are as low as possible, and in the longer term to create secure asset and capital structures. The tasks involved in financial management in a planning office include establishing a well-structured accounting department, careful cost accounting, sound budgeting and an effective controlling system. On the basis of a practical financial structure for architecture and engineering offices, the “financial management” module presents the information needed to carry these tasks out in a professional and responsible way.</td>
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<td>072-0405-00L</td>
<td>Module 5: Digitalisation</td>
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<tr>
<td>Abstract</td>
<td>Key terms: Strategy, potentials and digital planning</td>
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<tr>
<td>Objective</td>
<td>The aim is to become familiar with the current practical work involved in IT in planning companies and be able both to analyze the specific challenges it implies and also to infer one’s own prospects for development in this context. In addition, thought needs to be given to the way in which the value creation provided by digitalisation influences one’s own company.</td>
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<td>Content</td>
<td>IT refers on the one hand to information and data processing in a company, and on the other to the hardware and software components needed for the purpose. This “information technology” module focuses on potential strategies for company management in the IT field. The focus is not on the use of any individual programme, but on taking conscious decisions for or against IT components in one’s own company in order to obtain helpful support in one’s everyday work. The strengths, weaknesses, opportunities and risk of this strategy suggest possible potentials. The participants will present their own theses on entrepreneurship and open them up for discussion in the plenary session.</td>
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</tr>
</tbody>
</table>

### Term Paper

*Offered in the Spring Semester.*
<table>
<thead>
<tr>
<th></th>
<th>CAS ARC in Unternehmensführung - Key for Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

| V | lecture  |
| G | lecture with exercise  |
| U | exercise  |
| S | seminar  |
| K | colloquium  |
| P | practical/laboratory course  |
| A | independent project  |
| D | diploma thesis  |
| R | revision course / private study  |

ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
CAS in Advanced Materials and Processes

Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>344-0100-00L</td>
<td>CAS Module in Advanced Materials and Processes</td>
<td>O</td>
<td>12 credits</td>
<td>26A</td>
<td>Professors</td>
</tr>
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</table>

Abstract
CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in 'Advanced Materials and Processes'. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

Objective
The CAS AMaP module is fully customisable, building on the expertise of technical specialist professionals and aims at:
- training skills at the frontiers of the current state of research in Advanced Materials and Processes,
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

Content
Depending on individual interests and needs of the technical specialist professionals, the CAS AMaP module consists of the elements:
I. conducting a research project in the mentor’s group, addressing fundamental, development or applied problems, considering theoretical and/or experimental aspects,
II. individual schedule of courses and lectures with state-of-the-art knowledge, and
III. sharing of know-how in, e.g. seminars and interactive formats, thereby enhancing bidirectional knowledge transfer.

CAS in Advanced Materials and Processes - Key for Type

| W+          | Eligible for credits and recommended                      | Z    | Courses outside the curriculum |
| W           | Eligible for credits                                     | Dr   | Suitable for doctorate         |
| E-          | Recommended, not eligible for credits                    | O    | Compulsory                     |

Key for Hours

| V           | lecture                                                   | P    | practical/laboratory course    |
| G           | lecture with exercise                                     | A    | independent project           |
| U           | exercise                                                  | D    | diploma thesis                |
| S           | seminar                                                   | R    | revision course / private study|
| K           | colloquium                                               |      |                                  |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Applied Earth Sciences

► Modules Geo-Resources

The Module Geo-Resources runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS22 + HS22

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>669-0102-00L</td>
<td>Autumn Course: Geothermal Usage of the Subsurface</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>M. O. Saar, P. Bayer, M. Brehme</td>
</tr>
<tr>
<td></td>
<td>Only for CAS in Angewandten Erdwissenschaften.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The block course focuses on shallow groundwater wells and ground heat exchangers, but also expands the spectrum to include geothermal energy and geostorage potential in Switzerland. The contributions address, among other things, the question of how, with increased use of geothermal resources, conflicts of use due to the growing number of uses can be dealt with.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The aim of the course is for participants to be able to describe the basic processes of geothermal use and to understand the regulatory framework. They will be able to assess the mutual influence of the uses and know possibilities to take these into account in strategic planning.</td>
<td></td>
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</table>

► Modules Geo-Constructions

The Module Geo-Contructions runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS23 + HS23

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>669-0202-00L</td>
<td>Autumn Course: Engineering Geology in Underground Constructions</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>to be announced</td>
</tr>
<tr>
<td></td>
<td>Only for CAS in Angewandten Erdwissenschaften.</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

► Modules Geo-Risks

The Module Geo-Risks runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS24 + HS24

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>669-0302-00L</td>
<td>Autumn Course: Landslide Processs and Hazards</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>A. Manconi, to be announced</td>
</tr>
<tr>
<td></td>
<td>Only for CAS in Angewandten Erdwissenschaften.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The autumn course covers landslides in the broader sense, large slope movements and flowing mass movements in soil and rock. The course provides current and new knowledge needed for classification, determination of the relevant processes and estimation of the temporal behaviour of geological mass movements.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The participants learn which investigations and measurements can be used to improve the hazard analysis in a targeted manner, especially for more complex slope instabilities.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

CAS in Applied Earth Sciences - Key for Type

O     Compulsory
W+    Eligible for credits and recommended
W     Eligible for credits
E-    Recommended, not eligible for credits
Z     Courses outside the curriculum
Dr    Suitable for doctorate

Key for Hours

V     lecture
G     lecture with exercise
U     exercise
S     seminar
K     colloquium
P     practical/laboratory course
A     independent project
D     diploma thesis
R     revision course / private study

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Further Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-0649-02L</td>
<td>Applied Statistical Regression II</td>
<td>Z</td>
<td>2 credits</td>
<td>1V+1U</td>
<td>M. Mächler</td>
</tr>
<tr>
<td>447-0625-02L</td>
<td>Applied Analysis of Variance and Experimental Design II</td>
<td>Z</td>
<td>3 credits</td>
<td>1V+1U</td>
<td>L. Meier</td>
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<tr>
<td>447-6221-00L</td>
<td>Nonparametric Regression</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>M. Mächler</td>
</tr>
<tr>
<td>447-6257-00L</td>
<td>Repeated Measures</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>L. Meier</td>
</tr>
<tr>
<td>447-6289-00L</td>
<td>Sampling Surveys</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>B. Hulliger</td>
</tr>
<tr>
<td>447-6201-00L</td>
<td>Nonparametric and Resampling Methods</td>
<td>Z</td>
<td>2 credits</td>
<td>2G</td>
<td></td>
</tr>
</tbody>
</table>

## Literature
Spatial Statistics

**447-6233-00L**

**W**

1 credit

1G

**Abstract**

Does not take place this semester.

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

**Objective**

Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.

For classical parametric models there exist optimal statistical estimators and test statistics whose distributions can often be determined exactly. The methods covered in this course allow for finding statistical procedures for more general models and to derive exact or approximate distributions of complicated estimators and test statistics.

**Content**

Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.

**Prerequisites / notice**

This course is part of the programme for the certificate and diploma in Advanced Studies in Applied Statistics. It is given every second year in the winter semester break.

**Taught competencies**

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Literature**


**Applied Bayesian Statistics**

**447-6273-00L**

**W**

2 credits

2G

S. Robert

**Abstract**

Introduction to Bayesian statistics: basics of inference, computation with MCMC, linear model, logistic regression, Bayesian hierarchical models. Focus on applications and hands-on programming.

**Objective**

- understand the basics of Bayesian inference
- use R packages to run MCMC algorithms
- fit and understand Bayesian linear models
- introduction to hierarchical Bayesian models

**Content**

We will learn how to describe business/scientific problems as probabilistic models, apply Bayes rules to draw inference from data, and use the probabilistic programming language STAN to obtain samples from posterior distributions.

On the way we will fit linear models both for continuous and categorical outcomes, and explore techniques to deal with hierarchical structures in the data. There will be examples of applications from various fields: insurance, meteorology, marketing, etc.

**Literature**

"Bayes Rules! An Introduction to Applied Bayesian Modeling", Alicia A. Johnson, Miles Q. Ott, Mine Dogucu - CRC Press 2022

**Prerequisites / notice**

- introductory statistics
- applied regression
- R

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Objective
Getting to know the typical properties of financial data and appropriate statistical models, incl. the corresponding functions in R.

Block course on analysis of high-dimensional data with a focus on prediction and feature assessment.

The goal of this course is to gain a good understanding of the concepts discussed during the lecture and to apply the new methods on real data examples using the software "R". The topics covered in the lecture are:

Part 1: Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization

Part 2: Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

Course on Analysis of High-Dimensional Data with focus on Prediction and Feature Assessment.

Part 1: Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization

Part 2: Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

The block course is based on lecture notes (https://bookdown.org/staedler_n/highdimstats/).


Prerequisites / notice
The exercises are done exclusively with the (free, open source) software "R" (http://www.r-project.org). A final exam will also happen at the computers, using R (and your brains!).
Participants understand basic concepts of visual recognition and human-computer interaction systems.

L. E. Fässler
Recommended, not eligible for credits

Type
Title
Data Science

Lecturers
B. Gärtner

Hours
Eligible for credits and recommended
3V

Eligible for credits
The following programming concepts are introduced during this module:

- Variables, data types
- Condition check, Loops, logics
- Arrays
- Functions
- Matrices
- Data management (SQL)

In the practical part of the course, students work on small programming projects with a context from natural sciences. Electronic tutorials are available as preparation.

Prerequisites / notice
No prior knowledge is required for this course. It is based on application-oriented learning. The students spend most of their time working through programming projects and discussing their results with teaching assistants. To learn the programming basics there are electronic tutorials available.

265-0100-00L
Foundations of Programming

Only for CAS in Applied Information Technology and MAS in Applied Technology.

Abstract
The initial module offers a practical introduction to some basic concepts and techniques for information processing as well as practical applications of them. The programming language are Python and SQL.

Objective
Students learn...

- how to encode a problem into a program, test the program, and correct errors.
- to understand and improve existing code.
- to implement mathematical models as a simulation.

Content
The following programming concepts are introduced during this module:

1. Variables, data types
2. Condition check, Loops, logics
3. Arrays
4. Functions
5. Matrices
6. Data management (SQL)

Prerequisites / notice

Data Science

Only for CAS in Applied Information Technology and MAS in Applied Technology.

Abstract
In this module, basic paradigms and techniques in working with data will be discussed, especially towards data security, managing data decentrally, and learning from data.

Objective
Participants learn about some important computer science concepts necessary for data science. They understand some of these concepts in detail and see the mathematics behind them.

Content
Participants will get an introduction to key computer science concepts underlying current and upcoming technology. The module in particular covers cryptography and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). Each topic will be discussed in two different ways: (i) a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments; (ii) a context part that addresses the challenges and limitations encountered in practical applications.

265-0101-00L
Data Science

Only for CAS in Applied Information Technology and MAS in Applied Technology.

Abstract
This module offers practical knowledge in visual information processing and human computer interactions.

Objective
Participants understand basic concepts of visual reognition and human-computer interaction systems.

Content
Participants will get an introduction to key computer science concepts underlying current and upcoming technology. The module in particular covers cryptography and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). Each topic will be discussed in two different ways: (i) a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments; (ii) a context part that addresses the challenges and limitations encountered in practical applications.

265-0102-00L
Data Modeling and Computer Vision

Only for CAS in Applied Information Technology and MAS in Applied Technology.

Abstract
This module offers practical knowledge in visual information processing and human computer interactions.

Objective
Participants understand basic concepts of visual reognition and human-computer interaction systems.

Content
Participants will get an introduction to key computer science concepts underlying current and upcoming technology. The module in particular covers cryptography and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). Each topic will be discussed in two different ways: (i) a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments; (ii) a context part that addresses the challenges and limitations encountered in practical applications.

265-0103-00L
Applied Information Technology

Only for CAS in Applied Information Technology and MAS in Applied Technology.

Abstract
This integration module for CAS “Applied Information Technology” links technical understanding of technology with business strategy based on a set of case studies from practice.

Objective
Participants will learn how technology affects businesses and practical issues when using new technologies in incumbent organizations based on a set of case studies.

Content
Participants will explore how new information technologies change different aspects of a business, and learn how to evaluate specific risks, costs, and benefits of such technologies. The module will shed light on success factors and common pitfalls when implementing new technologies and respective business changes, and it will specifically address the communication between technical experts and business management. The studied cases are currently planned to focus on artificial intelligence, IoT including edge and cloud computing, blockchain and distributed ledger technologies, and cybersecurity and data protection regulations (subject to change).

CAS in Applied Information Technology - Key for Type

O
- Compulsory
- Eligible for credits

W+
- Eligible for credits and recommended

W
- Eligible for credits

E-
- Recommended, not eligible for credits

Z
- Courses outside the curriculum

Dr
- Suitable for doctorate

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 414 of 2345
### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Description</th>
</tr>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
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<td>K</td>
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<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

**ECTS**  
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
CAS in Applied Manufacturing Technology
The CAS takes place in Spring Semester only.
Start of the next course: FS 2023

CAS in Applied Manufacturing Technology - Key for Type

<table>
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</table>

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
The CAS takes place in Spring Semester only.

**CAS in Applied Technology in Energy - Key for Type**

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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<td>E-</td>
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**ECTS**

European Credit Transfer and Accumulation System

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The CAS takes place in Autumn Semester only.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>247-0200-00L</td>
<td>Fundamentals of R&amp;D and Innovation</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>U. Grossner, C. Ganz</td>
</tr>
<tr>
<td></td>
<td>(Only for CAS in Applied Technology: R&amp;D and Innovation and MAS in Applied Technology.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides an introduction to research &amp; development, both as a general activity and as a dedicated function within a corporation. Participants will learn how to organize, conduct, and manage individual R&amp;D projects as well as groups of projects. Special emphasis will be given to scientific and technical reporting.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The course provides the framework of organization, managing and reporting of R&amp;D projects and innovation initiatives.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>The module will be based on a self-study Polybook.</td>
<td></td>
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</tr>
<tr>
<td>247-0201-00L</td>
<td>Innovation – What Is and to What Purpose Do We Need It?</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>U. Grossner, C. Ganz</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The Innovation Opportunity Analysis course is designed as a practical introduction to evaluating technology-based innovation opportunities in a corporate setting. The course will cover several fundamental innovation frameworks and principles before diving deeper into individualized content using the principle of Guided Learning.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The primary goal of the course is to develop the skills needed for identifying technology-based innovation opportunities and for planning successful innovation projects. An additional goal is to prepare participants for their Master's thesis and for life-long learning in technology-based innovation.</td>
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<tr>
<td>247-0202-00L</td>
<td>R&amp;D: The Engine of Innovation</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>U. Grossner, C. Ganz</td>
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<td>(Only for CAS in Applied Technology: R&amp;D and Innovation and MAS in Applied Technology.)</td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>The inner working of the R&amp;D organization by exploring roles and processes is investigated.</td>
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<tr>
<td>Objective</td>
<td>The aim of this course is to develop the participants’ ability to articulate a coherent plan for R&amp;D activities linked to the business needs of a corporation, and to set the environment to enable an efficient R&amp;D organization.</td>
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<tr>
<td>Content</td>
<td>In most organizations, the R&amp;D organization is the one that delivers the innovation to be brought to the market. In this module, we investigate the inner working of the R&amp;D organization by exploring roles and processes. Since R&amp;D almost always starts with significant uncertainties and unsolved technical problems, governing R&amp;D has to account for these unknowns. As R&amp;D processes take time in which the market environment may change in ways other than predicted at the beginning of a project, external influences have to be continuously monitored as well to enable market success.</td>
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<td>247-0203-00L</td>
<td>The Innovation Ecosystem</td>
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<tr>
<td>Abstract</td>
<td>This module wraps up the various aspects of innovation beyond the own organization.</td>
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<tr>
<td>Objective</td>
<td>The goal of this module is to complete the R&amp;D and innovation framework and make the key points available in the context of the organizations' environment.</td>
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<tr>
<td>Content</td>
<td>Successful innovation builds on a whole ecosystem of contributors: customer co-creation, university collaboration, strategic partnerships, or start-up investments are just a few examples of activities where other players may expedite the innovation process. Other aspects of the environment of innovation covers intellectual property strategy, or standardization and certification. In addition to successfully operating in the existing business ecosystem, innovation may transform it, or even create new ecosystems, with innovative business models. In this module we will look at these various aspects of innovation beyond the own organization. This module will wrap up the CAS and put the material in context of the organization’s environment.</td>
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CAS in Applied Technology: R&D and Innovation - Key for Type

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Key for Hours

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<td>U</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Cyber Security

The CAS takes place in Autumn Semester only.

Modules

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<th>Number</th>
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<td>268-0101-00L</td>
<td>Introduction to Information Security</td>
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<td>5</td>
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<td>P. Schaller, S. Matetic</td>
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<tr>
<td>Abstract</td>
<td>In this course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students' understanding of the theory parts.</td>
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<tr>
<td>Objective</td>
<td>Graduates of the course know the technical foundations of information security and understand the difficulty and complexity involved when trying to build secure systems.</td>
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<tr>
<td>Content</td>
<td>In this new course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students' understanding of the theory parts.</td>
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<tr>
<td>Abstract</td>
<td>Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.</td>
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<tr>
<td>Objective</td>
<td>Participants have understood and presented a publication or report on a present topic in information security. By attending other participants presentations students get further introduced to additional current information security related topics/incidents.</td>
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<tr>
<td>Content</td>
<td>Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.</td>
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<tr>
<td>Abstract</td>
<td>This course is composed of various sub-modules related to Cyber Security taught by experts on the relevant fields.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students are expected to see behind the curtain of current research and engineering activities related to Cyber Security. At the same time students are introduced to contemporary challenges in cyber security by renowned experts.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>The lectures cover contemporary aspects and challenges in Cyber Security. The goal is to present current fields of research/engineering and the latest results. By way of example, Cyber Security Policy is one of sub-modules presented by researchers of the Center for Security Studies at ETH. Besides faculty members of the computer science department, there will be guest lecturers from industry presenting Cyber Security related challenges in their field of activity.</td>
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<td>Literature</td>
<td>Will be announced during the course.</td>
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CAS in Cyber Security - Key for Type

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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>375-0003-00L</td>
<td>Designing a Digital Biomarker (Group Project 2) Only for CAS in Digital Health</td>
<td>O</td>
<td>4 credits</td>
<td>1G</td>
<td>F. Da Conceição Barata, F. Wortmann</td>
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</tbody>
</table>

**Abstract**
The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

**Objective**
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world's aging population and the ever-growing number of chronic patients. However, this premise is based on the application of information and communication technologies that allow us to monitor patient data in many different ways. In this course, we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present, and apply the newly gained knowledge in a project.

1. Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.
2. Consumer-centric device data: Today, vast amounts of physiological, environmental, and behavioural observations can be collected with consumer-centric devices. However, deriving meaningful information from this data is difficult. We will analyze strategies for extracting knowledge from these measurements.
3. Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of machine learning domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantages as well as alternative methods for their application to digital biomarker data.
4. Applications: Digital biomarkers are still an emerging subfield but given that longitudinal digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant applications will emerge in the near future. We will review and discuss current applications and challenges.

**Content**
The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1. **Objective:** Students should:
   - understand the anatomy of digital biomarkers
   - understand the potential and applications of digital biomarkers
   - be able to critically reflect and assess existing digital biomarkers
   - be able to design and implement a digital biomarker

2. **Objective:** After this module, participants will be able to…

3. **Prerequisites / notice**
   - This module is assessed based on the participant's pass/fail status of the group project (including a presentation). The project involves the development of a procedure for collecting smartwatch data and applying analytical methods to predict sleep-related outcomes. Further details will be given at the beginning of the module.

4. **Prerequisites / notice**
   - This module is assessed based on the participant's pass/fail status of the group project (including a presentation). The project involves the development of a procedure for collecting smartwatch data and applying analytical methods to predict sleep-related outcomes. Further details will be given at the beginning of the module.

**Literature**


**Prerequisites / notice**

This module is assessed based on the participant's pass/fail status of the group project (including a presentation). The project involves the development of a procedure for collecting smartwatch data and applying analytical methods to predict sleep-related outcomes. Further details will be given at the beginning of the module.

**Modules in Digital Health**

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<tr>
<th>Number</th>
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<tr>
<td>375-0004-00L</td>
<td>Designing a Just-in-time Adaptive Intervention (Group Project 3) Only for CAS in Digital Health</td>
<td>O</td>
<td>4 credits</td>
<td>2G</td>
<td>T. Kowatsch</td>
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</tbody>
</table>

**Abstract**

Today, we face the challenge of chronic conditions. Personal coaching approaches are neither scalable nor financially sustainable. The question arises therefore to which degree Digital Health Interventions (DHIs) are appropriate to address this challenge. In this CAS module, students will design, implement and evaluate a DHI, esp. a just-in-time adaptive intervention.

**Objective**

After this module, participants will be able to…

1. understand the importance of just-in-time adaptive interventions (JITAIs), esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAIs
3. discuss opportunities and challenges of JITAIs

What are the implications and rationale behind the recent developments in the field of digital health?

Digital Health is the use of information and communication technology for the prevention and treatment of diseases in the everyday life of individuals. It is thus linked to topics such as digital health interventions, digital biomarkers, digital coaches and healthcare chatbots, telemedicine, mobile and wearable computing, self-tracking, personalized medicine, connected health, smart homes, or smart cars.

In the 20th century, healthcare systems specialized in acute care. In the 21st century, we now face the challenge of dealing with the specific characteristics of non-communicable diseases (NCDs). NCDs are now responsible for around 70% of all deaths worldwide and 85% of all deaths in Europe and are associated with an estimated economic loss of $7 trillion between 2011 and 2025. NCDs are characterized in particular by the fact that they require an intervention paradigm that focuses on prevention and lifestyle change. Lifestyle (e.g., diet, physical activity, tobacco, or alcohol consumption) can reduce the risk of suffering from a chronic condition or, if already present, can reduce its burden. A corresponding change in lifestyle is, however, only implemented by a fraction of those affected, partly because of missing or inadequate interventions or health literacy, partly due to socio-cultural influences. Individual personal coaching of these individuals is neither scalable nor financially sustainable.

To this end, the question arises on how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, behavioral medicine, information systems research, and computer science, this CAS module has the objective to help participants interested in the multi-disciplinary field of digital health to better understand the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions (JITAIs).

After this module, participants will be able to...

1. understand the importance of JITAIs, esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAIs
3. discuss opportunities and challenges of JITAIs

The CAS module is structured in two parts and follows the concept of a blended treatment consisting of live sessions and complementary online material. In the live sessions, participants will learn relevant topics. Complementary learning material (e.g., video clips), multiple-choice questions, and exercises are provided via the online learning platform.

In the second part, participants work in teams and will use their knowledge from the first part of the module to develop a smartphone-based and chatbot-delivered JTAI with MobileCoach (www.mobile-coach.eu), an open-source software platform for the development of digital biomarker and digital health interventions. Each team will then present and discuss the resulting JTAI and evaluation results with their colleagues who will provide peer reviews. Additional live coaching sessions are offered to support the teams with the design and evaluation of their JITAIs, and with the preparation of the final group project presentations.

### Literature


### Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Analytical Competences</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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Data: 18.08.2022 12:39 - Autumn Semester 2022 - Page 421 of 2345
### CAS in Digital Health - Key for Type

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<tr>
<td>373-0100-00L</td>
<td>Entrepreneurial Strategies</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>B. Clarysse</td>
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<td></td>
<td>Only for CAS in Entrepreneurial Leadership in Technology Ventures.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This is the first knowledge module in the CAS ELTV. In this module we (1) introduce all participants to the CAS and ETH, (2) get to know in more detail the projects of the participants and how lean innovation plays a role, and (3) discuss important considerations of strategy formation in technology ventures.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>This module enables participants:</td>
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<td></td>
<td>- To understand and select from commercialization strategies available to them (e.g., licensing, partnering, and vertical integration) and respective business model choices</td>
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<td></td>
<td>- Assess and generate development options for key internal enabling factors such IP strategy and key resources and capabilities</td>
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<td></td>
<td>- Understand different market research tools (lean start-up vs. technology broadcasting) and select appropriate methods and related KPIs</td>
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<td><strong>Content</strong></td>
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<td>This module focuses on elements of entrepreneurial strategy formation and implementation in nascent markets and/or industries. Participants will study commercial options available to them, e.g., technology broadcasting, licensing and partnering, and vertical integration, which is complemented by a practical view on IP strategy, driven by business strategy rather than arbitrary choices. The module also includes the introduction to lean innovation methods incl. agile product development methods and core tools of the lean startup approach.</td>
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<td>Lecture notes</td>
<td>See Online Platform</td>
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<tr>
<td>Literature</td>
<td>See Online Platform</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This module is only for CAS ELTV participants.</td>
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</table>

| 373-0101-00L   | Entrepreneurial Leadership and Teams       | O    | 1    | 1G    | J. Thiel           |
|                | Only for CAS in Entrepreneurial Leadership in Technology Ventures. |      |      |       |                    |
|                | **Abstract**                               |      |      |       |                    |
|                | This is the second knowledge module within the CAS ELTV. During this module, we will discuss important themes concerning entrepreneurial team formation and management and practice elements in interactive workshops. |      |      |       |                    |
|                | **Objective**                              |      |      |       |                    |
|                | This module enables participants:          |      |      |       |                    |
|                | - To understand key requirements for new venture leadership and how to build effective governance structures for the founding team |      |      |       |                    |
|                | - To select and implement approaches and methods to structure productive work relationships within an emerging firm. |      |      |       |                    |
|                | - To understand and build the organizational foundations for successful professionalizing of venture operations |      |      |       |                    |
|                | **Content**                                |      |      |       |                    |
|                | This module zooms in on the design and management of new venture teams in technology-based companies as well as the role of leadership in building successful venture teams. Key contents in this module comprise founder contracts, successful governance structures, and approaches to team performance management. This module also allows participants to understand requirements for venture leadership and professionalizing venture operations as well as building productive work relationship within their emerging firm. |      |      |       |                    |
| Lecture notes  | See Online Platform                        |      |      |       |                    |
| Literature     | See Online Platform                        |      |      |       |                    |
| Prerequisites / notice | This module is for CAS ELTV participants only. |      |      |       |                    |

| 373-0102-00L   | Entrepreneurial Marketing & Sales          | O    | 1    | 1G    | M. Gruber          |
|                | Only for CAS in Entrepreneurial Leadership in Technology Ventures. |      |      |       |                    |
|                | **Abstract**                               |      |      |       |                    |
|                | This is the third knowledge module within the CAS ELTV. During this module, we will discuss important themes concerning entrepreneurial team formation and management and practice elements in interactive workshops. The module will be extended by intermediary project review meetings. |      |      |       |                    |
|                | **Objective**                              |      |      |       |                    |
|                | This module enables participants:          |      |      |       |                    |
|                | - To understand customer needs and the respective markets |      |      |       |                    |
|                | - To practice and optimize successful communication with and towards existing and future customers (e.g., strategic selling, key account management, communication tools). |      |      |       |                    |
|                | - To understand and use different pricing techniques for technology products and services, both in B2C and B2B contexts, |      |      |       |                    |
|                | - To select appropriate strategies to build up effective sales channels and calculate and optimize respective funnel KPIs and assess the implications on the venture's business model and organization (e.g., lead management, funnel metrics, etc.) |      |      |       |                    |
|                | **Content**                                |      |      |       |                    |
|                | This module exposes participants to important customer development and market research strategies, with the goal to build competencies in several customer-facing activity domains of the growing venture. Key module themes span the pricing of technology products and services, both in B2C and B2B contexts, the effective build-up of sales channels and funnels, and the successful communication to existing as well as future customers. |      |      |       |                    |
| Lecture notes  | See Online Platform                        |      |      |       |                    |
| Literature     | See Online Platform                        |      |      |       |                    |
| Prerequisites / notice | This module is for CAS ELTV participants only. |      |      |       |                    |

| 373-0200-00L   | Business Development of Technology Ventures I | O    | 2    | 2P    | B. Clarysse        |
|                | Only for CAS in Entrepreneurial Leadership in Technology Ventures. |      |      |       |                    |
|                | **Abstract**                               |      |      |       |                    |
|                | This module is the first part of the Business Coaching track of the CAS ELTV. The module offers a structured process through which participants develop their business projects. All projects receive regular guidance from a dedicated coach. |      |      |       |                    |
|                | **Objective**                              |      |      |       |                    |
|                | This module enables participants:          |      |      |       |                    |
|                | - To identify key unknowns and important progress measures for their respective business case and implement effective means and tools to further develop their business case |      |      |       |                    |
|                | - To understand the view of potential customers and implement their feedback to improve the business case |      |      |       |                    |
|                | **Content**                                |      |      |       |                    |
|                | This module focuses on the development needs of participants' business skills and competencies. In this module, experienced business coaches and startup mentors will interact regularly with the participants, offer guidance on how to strategize and implement compelling business cases, feedback on specific challenges, and participants' activities with the goal to strengthen the ability of the participant to garner needed resources for their undertakings. |      |      |       |                    |
| Lecture notes  | See Online Platform                        |      |      |       |                    |
| Literature     | See Online Platform                        |      |      |       |                    |
| Prerequisites / notice | This module is for CAS ELTV participants only. |      |      |       |                    |
### Leadership Development I

**373-0201-00L**

**Leadership Development I**
Only for CAS in Entrepreneurial Leadership in Technology Ventures.

<table>
<thead>
<tr>
<th>Credit</th>
<th>M</th>
<th><strong>B. Clarysse</strong></th>
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<tbody>
<tr>
<td>1</td>
<td>O</td>
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<tr>
<td>1P</td>
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</tbody>
</table>

**Abstract**
This is the first module of the Leadership Development & Coaching track of the CAS ELTV. In this module, participants take stock of their current situation and goals and develop specific action points. This process is supported by experienced leadership coaches.

**Objective**
This module enables participants:
- To identify current gaps in the personal management skills and competencies and develop meaningful goals and plans to fill those gaps
- To implement effective exercises and practices to improve the participants' leadership capacity
- To effectively communicate and manage key constituents, notably employees and key advisors in a venture project

**Content**
This module focuses on the development needs of participants' leadership competencies. In this module, experienced leadership coaches will interact regularly with the participants, coach them along a personal development plan, and feedback participants on specific challenges and activities with the goal to strengthen the participants' leadership capability and people skills.

### Final Business Project Defense

**373-0205-00L**

**Final Business Project Defense**
Only for CAS in Entrepreneurial Leadership in Technology Ventures.

<table>
<thead>
<tr>
<th>Credit</th>
<th>M</th>
<th><strong>B. Clarysse, J. Thiel, to be announced</strong></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>O</td>
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</table>

**Abstract**
This module focuses on the development needs for both the participants' presentation and resource mobilization skills. The participants are asked to bring all learnings from the CAS and defend in engaging manner their business projects. This defense is typically delivered in presence of external investors or venture stakeholders who will challenge the project and potentially offer future support.

**Objective**
This module enables participants:
- To reflect upon and integrate important and relevant elements from the CAS into the venture project
- To practice effective business communication and venture pitching skills
- To receive and handle challenging feedback from important venture constituents.

### CAS in Entrepreneurial Leadership in Technology Ventures - Key for Type

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

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

### CAS in Entrepreneurial Leadership in Technology Ventures - Key for Hours

- **ECTS**: European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>865-0065-00L</td>
<td>VET between Poverty Alleviation and Economic Development</td>
<td>W</td>
<td>2</td>
<td>3G</td>
<td>K. Hartgen, F. Kehl, M. Maurer</td>
</tr>
<tr>
<td></td>
<td>Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation.</td>
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<tr>
<td></td>
<td>ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.</td>
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<td>Registration only through the NADEL administration office.</td>
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<td></td>
<td>The course aims at strengthening the capacity in portfolio management for VET, skills development and active labor market policies. It deals with basic issues and challenges of Vocational Education and Training (VET) in Developing Countries. In view of the many of school leavers VET has to place itself between the contradicting intensions of quality education and short-term training interventions.</td>
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<td>The participants are able to</td>
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<td>- Assess project proposals and ongoing project regarding their relevance and suitability in the specific country context</td>
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<td></td>
<td>- Explain strengths and weaknesses of the opposing approaches &quot;dual apprenticeship&quot; and &quot;competency based training&quot; as well as synergies and incompatibilities between the two</td>
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<td>- Describe the competent use of tools currently applied in VET</td>
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<td></td>
<td>• Basic concepts and terms</td>
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<td></td>
<td>• Differences and commonalities between VET and neighboring systems</td>
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<td></td>
<td>• Planning, assessment of VET interventions with different objectives: economic development, poverty alleviation, creation of self-employment or systems development</td>
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<td></td>
<td>• VET as a cooperation system of stakeholders with different duties, interests and competencies</td>
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<td></td>
<td>• Background, potential use and limitations of (national) qualification frameworks</td>
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<td></td>
<td>• Half-day visit to important actors of the Swiss VET landscape</td>
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<td>Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariate.</td>
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<tr>
<td>865-0000-01L</td>
<td>Planning and Monitoring of Projects</td>
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<td>2</td>
<td>3G</td>
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<td></td>
<td>Does not take place this semester.</td>
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<td></td>
<td>Only for CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation.</td>
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<td></td>
<td>ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.</td>
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<td>Registration only through the NADEL administration office.</td>
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<td>The course provides a deeper understanding of the methodological foundations of results-oriented planning and steering of development projects. Together with the participants, we reflect on the situation-specific application of instruments for project planning and the development of a monitoring system, which makes it possible to adapt and steer projects.</td>
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<td>The course participants are able to describe the processes and concepts of project planning and monitoring using the correct technical terminology, to initiate an analysis of the initial situation, to elaborate a monitoring system, and to adaptively steer the implementation of projects.</td>
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<td></td>
<td>• Basic concepts of result-oriented project management</td>
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<td>• Instruments and resources for project planning, including the elaboration of a &quot;logframe matrix&quot; and results chain</td>
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<td>• Instruments and resources for project monitoring, and for the development of a monitoring system, including indicators to assess objectives achievement and steer the Project</td>
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<td>• 'Write' and structure results-oriented Project reports</td>
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<td>Students of the course must fulfill requirements specified on the homepage of NADEL.</td>
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<tr>
<td>865-0064-00L</td>
<td>Decolonizing Aid</td>
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<td>3G</td>
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<td>Does not take place this semester.</td>
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<td></td>
<td>Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation.</td>
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<td>Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted &quot;sur Dossier&quot;.</td>
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<td>Registration only through the NADEL administration office.</td>
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<td>The course is designed to increase awareness of how cultural perceptions and power structures have influenced society and our understanding of aid practice in aid. It promotes alternatives to aid as linear and progressive Eurocentric narrative. The course draws on different theoretical perspectives and scrutinizes practical examples of aid interventions and similar initiatives.</td>
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<td>The course goes beyond awareness raising of personal cultural characteristics and recognizing cultural values within development concepts. It unfolds traces of colonialism and power structures in day to day live and the aid industry. It promotes searching and initiating alternatives to aid as a Eurocentric narrative. Participants get familiar with different theoretical perspectives on decoloniality and scrutinize practical examples of aid interventions and similar initiatives.</td>
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<tr>
<td></td>
<td>• Decolonialism key terms and concepts</td>
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<td></td>
<td>• Conceptions of and alternatives to development (cooperation)</td>
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<td></td>
<td>• Cultural (self-) awareness, diversity</td>
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<td></td>
<td>• The role of culture in aid / development cooperation</td>
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<td></td>
<td>• Implications of decolonialism for aid policy making and practice</td>
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<tr>
<td>865-0070-00L</td>
<td>The Private Sector and Development Organizations:</td>
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<td></td>
<td>Building Successful Alliances</td>
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<td>Does not take place this semester.</td>
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<td></td>
<td>Only for MAS/CAS in Development and Cooperation</td>
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</table>
students, as well as specialists with at least 24 months of practical experience in international cooperation. Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted "sur Dossier".

Registration only through the NADEL administration office.

Abstract

The following topics will be discussed: The political economy of the Corporate Social Responsibility discourse, voluntary governance regimes and development: theory of change and effectiveness of soft law approaches, PPPs: introducing concepts and taking stock of experience, analysis of private sector strategies from selected governance actors, engaging with the private sector.

Objective

This course seeks to increase the participants' understanding of the multifaceted and dialectic relationships between civil society, governments and private sector. It equips participants with knowledge and tools required for a strategic interaction between private sector organizations and development agencies. The course enables participants to contribute effectively to policy debates on the role of private sector actors and development.

Prerequisites / notice

Students of the course must fulfill requirements specified on the homepage of NADEL.

CAS in Development and Cooperation - Key for Type

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

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

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The course material will be made available by the lecturer. This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things. The course focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, and reflection.

**Prerequisites:**
- At least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

**Objective:**
After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.

**Content:**
The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different object-oriented languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

**Literature:**
Will be announced in the lecture.

**Prerequisites / notice**
Prerequisites:
- Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

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**Focus Courses and Electives**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0237-00L</td>
<td><strong>Concepts of Object-Oriented Programming</strong></td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
| **Objective**  | After this course, students will: 
|                | Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features. 
|                | Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs. 
|                | Be able to learn new languages more rapidly. 
|                | Be aware of many subtle problems of object-oriented programming and know how to avoid them. |
| **Content**    | The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different object-oriented languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages. |

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

**Literature**
Will be announced in the lecture.

**Prerequisites / notice**
Prerequisites:
- Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

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**Focus Courses and Electives**

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<tr>
<td>252-0293-00L</td>
<td><strong>Wireless Networking and Mobile Computing</strong></td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>S. Mangold</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Wireless Communication, Wi-Fi, Contact Tracing, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.</td>
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</tbody>
</table>
|                | Chapters: 
|                | 1 Introduction 
|                | 2 Wireless Communication Basics 
|                | 3 IEEE 802.11 Wireless LAN (Wi-Fi) 
|                | 4 IEEE 802.15 Wireless PAN (ZigBee & Bluetooth) 
|                | 5 Mobile Computing Algorithm Basics: Control and Game Theory 
|                | 6 Visible Light Communication 
|                | 7 Audio Communication 
|                | 8 Cellular Networking Basics (LTE, 5G, Internet-of-Things) 
|                | 9 Mobile Computing for Automated Medicine Delivery 
|                | 10 Cognitive Radio, Delay Tolerant Networking, Radio Spectrum Sharing |
| **Lecture notes** | The course material will be made available by the lecturer. |
| **Literature**  | (1) The course webpage (look for Stefan Mangold's site) 
|                | (2) The Java 802 protocol emulator “JEmula802” from https://bitbucket.org/lfield/jemula802 
| **Prerequisites / notice** | Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required). |
Taught competencies

Subject-specific Competencies
- Concepts and Theories: not assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

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

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

252-0417-00L Randomized Algorithms and Probabilistic Methods W 10 credits 3V+2U+4A A. Steger

Abstract
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

Objective
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes
Yes.

Literature

252-0463-00L Security Engineering W 7 credits 2V+2U+2A D. Basin, M. Ochoa Ronderos

Abstract
Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

Objective
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include
- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems
Content

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class

2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security

3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts

4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience

5. Model-driven security (Part II)
   - Continuation of above topics

6. Security patterns (design and implementation)

7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks

8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis

9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties

10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment

11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience

12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection

13. Guest lecture
    - TBA

Literature

- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice

Prerequisite: Class on Information Security

Abstract

Advanced Machine Learning

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.
Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensemble; Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-0543-01L  Computer Graphics  W  8 credits  3V+2U+2A  M. Gross, M. Papas

Abstract

This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

Objective

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

Content

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image-based rendering.

Lecture notes

no

Literature

Books:
- High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
- Multiple view geometry in computer vision
- Physically Based Rendering: From Theory to Implementation

Prerequisites / notice

Prerequisites:
- Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.

The programming assignments will be in C++. This will not be taught in the class.

252-0546-00L  Physically-Based Simulation in Computer Graphics  W  5 credits  2V+1U+1A  S. Coros, B. Thomaszewski

Abstract

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective

At the end of the course the students will be able to simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Content

The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Prerequisites / notice

Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

252-1411-00L  Security of Wireless Networks  W  6 credits  2V+1U+2A  S. Capkun, K. Kostiainen

Abstract

Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.

Objective

After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security protocols for wireless network; implement mechanisms to secure 802.11 networks.

252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde
Abstract The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.

Objective In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content The first part of the lecture covers individual system's aspects starting with tamperproof or tamperresistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

252-1425-00L Geometry: Combinatorics and Algorithms W 8 credits 3V+2U+2A B. Gärtner, E. Welzl, M. Hoffmann
Abstract Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

Objective The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Content Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in R^d, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Lecture notes yes


Prerequisites / notice Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

252-3005-00L Natural Language Processing W 7 credits 3V+3U+1A R. Cotterell
Number of participants limited to 400.
Abstract This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

227-2210-00L Computer Architecture W 8 credits 6G+1A O. Mutlu
Abstract Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

Lecture notes All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture/

The video recordings of the lectures are expected to be made available after lectures.

See https://safari.ethz.ch/architecture for past examples.

Literature We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

See https://safari.ethz.ch/architecture for past examples.
Reliable and Trustworthy Artificial Intelligence

Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

The course is split into 3 parts:

Robustness in Deep Learning

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Advanced topics in parallel and high-performance computing.

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

Number of participants limited to 125.

Design of Parallel and High-Performance Computing

Understanding concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

This combination of requirements, together with the technologies that have emerged in order to address them, is typically referred to as "Big Data." This revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that’s 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today’s technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.
Content

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Prerequisites / notice

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Literature

Course textbook: https://ghislainfourny.github.io/big-data-textbook/
Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

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- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz

Number of participants limited to 320.

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

- Advanced Machine Learning https://ml2.inf.ethz.ch/courses/aml/
- Computational Intelligence Lab http://da.inf.ethz.ch/teaching/2019/CIL/
- Statistical Learning Theory http://mi2.inf.ethz.ch/courses/slt/
- Probabilistic Artificial Intelligence https://las.inf.ethz.ch/teaching/pai-f18
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

The course will cover topics spanning four broad themes with a focus on the first two themes:

1. network defense mechanisms such as public-key infrastructures, TLS, VPsns, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

Formal methods are increasingly a key part of the methodological toolkit of systems programmers - those writing operating systems, databases and SQL.

By the end of the course, students should be able to seamlessly integrate basic concepts from formal methods into how they conceive, design, implement, reason about, and debug computer systems.

Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified seL4 microkernel will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

Informal Methods

Formal methods are increasingly a key part of the methodological toolkit of systems programmers - those writing operating systems, databases, and distributed systems. This course is about how to apply concepts, techniques, and principles from formal methods to such software systems, and how to get into the habit of thinking formally about systems design even when writing low-level C code.

This course is about equipping students whose focus is systems with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers. By the end of the course, students should be able to seamlessly integrate basic concepts from formal methods into how they conceive, design, implement, reason about, and debug computer systems.

The goal is not to provide a comprehensive introduction to formal methods - this is well covered by other courses in the department. Instead, it is intended to provide students in computer systems (who may or may not have existing background knowledge of formal methods) with a basis for applying formal methods in their work.

This course does not assume prior knowledge of formal methods, and will start with a quick review of topics such as logical reasoning, variants and invariants, program algebra and refinement, etc. However, it is strongly recommended that students have already taken one of the introductory formal methods course at ETH (or equivalents elsewhere) before taking this course - the emphasis is on reinforcing these concepts by applying them, not to teach them from scratch.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

This course will cover four broad themes with a focus on the first two themes:

1. network defense mechanisms such as public-key infrastructures, TLS, VPsns, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

Techniques and Technologies

The course is about equipping students whose focus is systems with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers.

This course provides an in-depth study of network attack techniques and methods to defend against them. Students have an in-depth understanding of a range of important state-of-the-art security technologies.

Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified seL4 microkernel will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).

This course is about equipping students whose focus is systems with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers.

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Artificial Intelligence in Education

**Abstract**
Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

**Objective**
The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

**Content**
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

**Lecture notes**
Lecture slides will be made available at the course Web site.

**Literature**
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

**Prerequisites / notice**
There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

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Probabilistic Artificial Intelligence

**Abstract**
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Content**
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**
Solid basic knowledge in statistics, algorithms and programming. The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

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Foundations of Reinforcement Learning

**Abstract**
This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

**Objective**
By the end of the course, students will be able to
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover "new" applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

**Content**
Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

**Lecture notes**
Lecture notes will be posted on Moodle.

**Literature**
Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Csizmeri.
Prerequisites / notice

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5353-00L Philosophy of Language and Computation W 5 credits 2V+1U+1A R. Cotterell, J. L. Gastaldi

Abstract

Understand the philosophical underpinnings of language-based artificial intelligence.

Objective

This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data.

Content

This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data. The course is a year-long journey, but the second half (Spring 2023) does not depend on the first (Fall 2022) and thus either half may be taken independently. In each semester, we divide the class time into three modules. Each module is centered around a philosophical topic. In the first semester we will discuss structuralism, recursive structure and logic, and in the second semester we will focus on language games and pragmatics. The modules will be four weeks long. During the first two weeks of a module, we will read and discuss original texts and supplementary materials. During the second two weeks, we will read recent NLP papers and discuss how the authors of these works are building on philosophical insights into our conception of language—perhaps implicitly or unthinkingly.

Literature

The literature will be provided by the instructors on the class website.

263-5902-00L Computer Vision W 8 credits 3V+1U+3A M. Pollefeys, S. Tang, F. Yu

Abstract

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective

The objectives of this course are:

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

263-5905-00L Mixed Reality W 5 credits 3G+1A I. Armeni, M. Pollefeys

Abstract

The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human interaction, as well as gaming technology.

Objective

After attending this course, students will:

1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

Content

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course is student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can range from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice

Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

636-0007-00L Computational Systems Biology W 6 credits 3V+2U J. Stelling

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content

Biology has witnessed a unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes

http://www.csb.ethz.ch/education/lectures.html

Literature


636-0017-00L Computational Biology W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Stadler

Abstract

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.
Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Literature
• Yang, Z. 2006. Computational Molecular Evolution.
• Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

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<th>Seminars</th>
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<tr>
<td><strong>Number</strong></td>
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<td>252-3811-00L</td>
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<td>252-4601-00L</td>
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<td>252-5051-00L</td>
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Abstract
Participants will learn how to analyze and solve IT problems in practice in a systematic way, present findings to decision bodies, and defend their conclusions.

Objective
Participants understand the different viewpoints for IT-decisions in practice, including technical and business aspects, can effectively analyze IT questions from the different viewpoints and facilitate decision making.

Content
Participants learn how to systematically approach an IT problem in practice. They work in groups of three to solve a case from a participating company in depth, studying provided materials, searching for additional information, analyzing all in depth, interviewing members from the company or discussing findings with them to obtain further insights, and presenting and defending their conclusion to company representatives, the lecturer, and all other participants of the seminar. Participants also learn how to challenge presentations from other teams, and obtain an overview of learnings from the cases other teams worked on.

Lecture notes
Methodologies to analyze the cases and create final presentations. Short overview of each case.

Prerequisites / notice
Successful completion of Lecture "Case Studies from Practice".

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<td>252-4601-00L</td>
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<td>252-5051-00L</td>
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Abstract | The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.

Content | The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from Computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

Literature | The papers will be presented in the first session of the seminar.

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<th>ECTS</th>
<th>Prerequisites / notice</th>
<th>Objective</th>
<th>Content</th>
<th>Literature</th>
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<tbody>
<tr>
<td>252-5701-00L</td>
<td>Seminar in Advanced Topics in Vision</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>M. Pollefeys, S. Tang</td>
<td>2 credits</td>
<td>The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from Computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.</td>
<td>The publications to be presented will be announced on the seminar home page at least one week before the first session.</td>
</tr>
<tr>
<td>263-2100-00L</td>
<td>Research Topics in Software Engineering</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>P. Müller, M. Püschel</td>
<td>2 credits</td>
<td>This seminar is an opportunity to become familiar with current research in software engineering and more generally with the methods and challenges of scientific research.</td>
<td>The aim of this seminar is to introduce students to recent research results in the area of programming languages and software engineering. To accomplish that, students will study and present research papers in the area as well as participate in paper discussions. The papers will span topics in both theory and practice, including papers on program verification, program analysis, testing, programming language design, and development tools. A particular focus will be on domain-specific languages.</td>
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<td>263-3504-00L</td>
<td>Hardware Acceleration for Data Processing</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>G. Alonso</td>
<td>2 credits</td>
<td>The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.</td>
<td>The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.</td>
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<tr>
<td>263-3713-00L</td>
<td>Advanced Topics in Human-Centric Computer Vision</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>O. Hilliges</td>
<td>2 credits</td>
<td>In this seminar we will discuss state-of-the-art literature on human-centric computer vision topics including but not limited to human pose estimation, hand and eye-gaze estimation as well as generative modelling of detailed human activities. The learning objective is to analyze selected research papers published at top computer vision and machine learning venues. A key focus will be placed on identifying and discussing open problems and novel solutions in this space. The seminar will achieve this via several components: reading papers, technical presentations, writing analysis and critique summaries, class discussions, and exploration of potential research topics.</td>
<td>Students taking this seminar should have the necessary background in systems and low level programming.</td>
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</table>
The goal of the seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and oral presentation skills. The seminar will have a different structure from regular seminars to encourage more discussion and a deeper learning experience.

We will treat papers as case studies and discuss them in-depth in the seminar. Once per semester, every student will have to take one of the following roles:

Presenter: Give a presentation about the paper that you read in depth.

Reviewer: Perform a critical review of the paper.

All other students: read the paper and submit questions they have about the paper before the presentation.

Prerequisites / notice
Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.

Taught competencies
Method-specific Competencies
Analytical Competencies
Social Competencies
Communication
Personal Competencies
Critical Thinking

263-5702-00L Seminar on Digital Humans
Number of participants limited to 24.

Abstract
This seminar covers advanced topic in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

Objective
The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills.

Content
This seminar covers advanced topics in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.

Literature
Individual research papers are selected each term. See https://vlg.inf.ethz.ch/ and http://graphics.ethz.ch/ for example papers.

263-5100-00L Topics in Medical Machine Learning
Number of participants limited to 18.

Abstract
This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold a presentation and lead the subsequent discussion.

Objective
Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.

Content
The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

Prerequisites / notice
Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

CAS in Computer Science - Key for Type

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<tr>
<th>Key for Hours</th>
<th>V</th>
<th>lecture</th>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>ECTS</td>
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<td>O</td>
<td>Compulsory</td>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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Special students and auditors need special permission from the lecturers.
CAS in International Policy and Advocacy

The CAS is offered once per year in the spring semester. Course duration: 1 Semester, part-time.

More information at: www.sspg.ethz.ch/en

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<th>CAS in International Policy and Advocacy - Key for Type</th>
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</table>

ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Future Transport Systems: New Business Models

The "CAS in Future Transport Systems: New Business Models" takes place only in Spring Semester

Start of the next course: Spring Semester 2023
Course duration: Six months part time
Periodicity: yearly


### CAS in Future Transport Systems: New Business Models - Key for Type

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
<th>Key for Hours</th>
<th>ECTS</th>
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<tr>
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<td>W+</td>
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<td>W</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>P</td>
<td>practical/laboratory course</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>independent project</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>R</td>
<td>revision course / private study</td>
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### Key for Hours

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium

### ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### CAS in Future Transport Systems: Systemic Aspects of Future Transport

The "CAS in Future Transport Systems: Systemic Aspects of Future Transport" takes place only in Spring Semester

Start of the next course: Spring Semester 2023
Course duration: Six months part time
Periodicity: Every two years


<table>
<thead>
<tr>
<th>Number</th>
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<td><strong>166-0100-00L</strong></td>
<td>Transport Systems: Dynamics and Future Developments</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>A. Erath Rusterholtz, P. J. de Haan van der Weg</td>
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<tr>
<td><strong>166-0101-00L</strong></td>
<td>Development and Assessment of Transport Scenarios</td>
<td>O</td>
<td>3</td>
<td>3G</td>
<td>A. Erath Rusterholtz</td>
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<tr>
<td><strong>166-0102-00L</strong></td>
<td>Foundations for the Design of Transport System Innovation and Change Processes</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>J. Schippl</td>
</tr>
</tbody>
</table>

**Abstract**

This module acquaints participants with current methods for developing and evaluating transport scenarios. These include analysis of the interrelationship of space and traffic; traffic modelling methods; and evaluation according to economic and planning criteria.

**Objective**

- are familiar with successful methods for developing transport scenarios and how to analyse and evaluate them. In particular, they know how to address the challenges of evaluating future forms of transport;
- are able to select a suitable method and determine an evaluation concept with relation to a specific problem.

**Content**

- Methodological foundations of traffic modelling (44-level model, activity-based model, agent-based simulation)
- Design and evaluation of transport scenarios using MATSim (traffic simulation) with a focus on transport with autonomous vehicles
- Interrelationship of space and traffic (accessibility measurement, settlement density and mixed usage) and what to consider in designing and evaluating transport scenarios
- Approaches to evaluation of traffic scenarios (cost-benefit analyses and their foundations, methodological limits), analysis of effects taking into account user group and space type
- Ecobalancing with Life Cycle Assessment (LCA) in addressing passenger and goods transport issues
- Development of case studies on shared transport and mobility with an activity- and agent-based transport simulation model

**Methods**

- Aggregated and activity-based transport demand models
- Agent-based simulation
- Cost-benefit analysis
- Accessibility analysis

**Case studies**

- Shared mobility
- Autonomous mobility
- Densified settlement development and slow forms of mobility

**Lecture notes**

Distributed at start of module

**Literature**

Distributed at start of module

**Prerequisites / notice**

Announced to students of the of the MAS / CAS at the beginning of the term.

---

Data: 18.08.2022 12:39   Autumn Semester 2022   Page 442 of 2345
In this module, innovation, change and transitions in transportation systems on different levels are discussed from different complementary perspectives. Both economic and social science approaches to the analysis, anticipation and governance of innovation processes are presented, discussed and applied to current issues. Topics are:

- Key figures, development and trends in air and shipping traffic.
- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Life Cycle Assessment (LCA) for questions in air and shipping traffic.
- Potential for holistic improvement in air and shipping traffic.
- Innovation today in the transportation/mobility system: theoretical basis and concrete examples.
- Emerging trends as new opportunities for innovation.
- Transition of socio-technical systems, co-evolution of technical and societal dynamics.
- The relevance of social acceptance and ethical aspects for innovations in mobility.

The participants deal with a current problem from the topics of CAS System Aspects.

- Communicate the results appropriately.
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Deepen selected content from module independently
- Know the possibilities and limits as well as pros and cons of different valuation methods used for air and shipping transport.
- Develop ideas for suitable indicators to evaluate scenarios in air and shipping traffic.
- Know the fundamental differences between air, shipping traffic compared to motorized individual transport and public transport.
- Are able to deduce differences between air and shipping traffic.
- Know the possibilities and limits as well as pros and cons of different valuation methods used for air and shipping transport.
- Understand the economic and social-science fundamentals of innovation and change processes in the area of transportation;
- To analyse the foundations, opportunities and challenges of disruption in mobility systems;
- To set this concepts and frameworks constructively in context to their own work practice.

Announced to students of the of the MAS / CAS at the beginning of the term.
CAS in Future Transport Systems: Technology Potential

The "CAS in Future Transport Systems: Technology Potential" takes place only in Autumn Semester

Start of the next course: Autumn Semester 2023
Course duration: Six months part time
Periodicity: Every two years


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>166-0200-00L</td>
<td>Technology Potential: Powertrain, Systems and Energy Carriers</td>
<td>O</td>
<td>3.5 credits</td>
<td>3G</td>
<td>C. Onder</td>
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<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>The module provides a foundation in the current situation and short- and middle-term development directions of powertrain and automotive engineering in the context of passenger &amp; goods transport. Corresponding energy sources and resulting consequences for the energy system are addressed. Participants will be enabled to identify potentials of these technologies and apply them to concrete problems.</td>
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<tr>
<td>Objective</td>
<td>Familiarity with conventional and alternative powertrain and automotive systems for future sustainable mobility, and the ability to identify and deploy their potential to address concrete problems.</td>
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<tr>
<td>Content</td>
<td>- Drive component efficiency rates and core fields</td>
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<td></td>
<td>- Drive and non-drive energy flow / Vehicle &quot;driving resistance&quot;</td>
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<td></td>
<td>- Energy chains (operating power only) and CO2 emissions to primary energy</td>
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<tr>
<td>Lecture notes</td>
<td>Distributed at start of module</td>
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<td>Literature</td>
<td>Distributed at start of module</td>
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<td>Prerequisites / notice</td>
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<tr>
<td>166-0201-00L</td>
<td>Potential of Spatial Information- and Communication Technologies</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
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<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>The digital revolution, spatial information and communication systems in particular, have a significant influence on the development of new transport systems. Participants acquire an in-depth understanding of the functionality and application potential of spatial information systems and services and of communication technologies for deployment in future transport systems and applications.</td>
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<tr>
<td>Objective</td>
<td>Familiarity with information and communication technologies (ICT) and spatial information technologies, and the ability to identify and utilise their potential to address concrete problems.</td>
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<tr>
<td>Content</td>
<td>- Functionality and application of geographic information systems (GIS) to represent and analyse transport systems (acquire, model, analyse and visualise geodata)</td>
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<td></td>
<td>- Deployment potentials of GIS and ICT for efficient transport solutions (tangible, non-tangible)</td>
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<td>- Functionality and application of mobile spatial information technologies in future transport systems</td>
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<td></td>
<td>- Methods of spatiotemporal analysis and geodata analysis</td>
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<td>- Technical aspects of information and communication technologies (ICT)</td>
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<td></td>
<td>- Modelling, simulation and assessment of traffic behaviour</td>
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<td></td>
<td>- Basics of autonomous driving</td>
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<td></td>
<td>- Legal aspects of geodata</td>
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<td></td>
<td>- Applications: Traffic behaviour in Switzerland; location based services for energy-efficient behaviour; GIS for the Zurich traffic system (multimodal)</td>
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<tr>
<td>Lecture notes</td>
<td>Distributed at start of module</td>
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<tr>
<td>Literature</td>
<td>Distributed at start of module</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Announced to students of the of the MAS / CAS at the beginning of the term.</td>
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<tr>
<td>166-0202-00L</td>
<td>Integrated Assessment of Technologies and Transport Systems</td>
<td>O</td>
<td>2 credits</td>
<td>1G</td>
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<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>The module provides a solid introduction to integrated technology assessment with regard to economic, ecological and social criteria. It introduces life cycle assessment (LCA), cost assessment, risk assessment and multi-criteria decision analysis. It also presents scenario analyses based upon energy-economic models which explicitly represent transport and energy-supply technologies.</td>
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<tr>
<td>Objective</td>
<td>An overview of suitable methods for analysing and evaluating technical systems (transport systems) and the ability to choose among them to address concrete problems</td>
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</table>
Content

(1) Introduction to and overview of integrated assessment
- Current status of transport in Switzerland and internationally
- Scope and goals of integrated assessment
- Sustainability: concept and practical implementation via criteria and indicators
- Overview of concepts and implementation methods

(2) Selected methods for assessing transport technologies and their application to current and future options
- Ecobalance / life cycle assessment (LCA)
- Location-specific assessment of health hazards and environmental pollution
- Risk analysis
- Internal cost assessment
- External cost assessment

(3) Integrated assessment of transport technologies
- Overall costs (internal and external)
- Multi-criteria analysis

(4) Analysis of transport scenarios
- Scenarios, influencing factors, policy and sustainability
- Approaches to scenario modelling
- Global mobility scenarios: examples

Overview of concepts and implementation methods

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

166-0203-00L Energy Carrier for the Mobility of the Future

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<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>166-0203-00L</td>
<td>Energy Carrier for the Mobility of the Future</td>
<td>O</td>
<td>3.5</td>
<td>3G</td>
<td>M. A. Streicher-Porte</td>
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</table>

Abstract
The module includes the supply of the road mobility of the future with renewable energy. The generation, transport, processing, transfer of energy to the vehicles (refueling, charging) and the energetic evaluation are presented. Electricity, hydrogen, biogenic and synthetic fuels are considered.

Objective
The aim of the module is a detailed energetic and technical understanding of the supply of road vehicles with renewable energy. Graduates know the primary energy production as well as the end energy processing of the different energy carrier concepts. In addition, they know the legal CO2 requirements for vehicle registration and are able to qualitatively assess the impact on the Swiss energy system.

Content
- The energy system of the future; biogenic and electric renewable primary energy
- End energy processing
- Transfer from the energy system to mobility and influences on the overall energy system

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

CAS in Future Transport Systems: Technology Potential - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>O</td>
<td>3</td>
<td>5D</td>
<td>M. A. Streicher-Porte</td>
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Key for Type
- O: Compulsory
- W+: Eligible for credits and recommended
- W: Eligible for credits
- E-: Recommended, not eligible for credits
- Z: Courses outside the curriculum
- Dr: Suitable for doctorate

Key for Hours
- V: lecture
- G: lecture with exercise
- U: exercise
- S: seminar
- K: colloquium
- P: practical/laboratory course
- A: independent project
- D: diploma thesis
- R: revision course / private study

ECTS
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## CAS in Modern Concepts in Clinical Research

### Modules

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<th>Number</th>
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<td>395-0100-00L</td>
<td>From Clinical Problem to Research Question</td>
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<td>1.5 credits</td>
<td>2G</td>
<td>S. Goldhahn, A. Frotzler, J. Steurer</td>
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<td>Only for CAS in Modern Concepts in Clinical Research and MAS in digital Clinical Research</td>
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<tr>
<td>395-0101-00L</td>
<td>Modern Study Concepts</td>
<td>O</td>
<td>1.5 credits</td>
<td>1G</td>
<td>A. Burden, S. Goldhahn, to be announced</td>
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<td></td>
<td>Only for CAS in Modern Concepts in Clinical Research and MAS in digital Clinical Research</td>
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<tr>
<td>395-0102-00L</td>
<td>Real-World Data</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>K. Crameri, C. Jutzeler, S. Österle</td>
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<td>395-0103-00L</td>
<td>Precision Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>S. Modica, A. Ghosh, C. Wolfrum</td>
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<td>Only for CAS in Modern Concepts in Clinical Research and MAS in digital Clinical Research</td>
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### CAS in Modern Concepts in Clinical Research - Key for Type

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<th>Z</th>
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<td>Suitable for doctorate</td>
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### Key for Hours

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<th>K</th>
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<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<th>A</th>
<th>D</th>
<th>R</th>
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<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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### ECTS

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- Special students and auditors need special permission from the lecturers.
CAS in Natural Hazard - Risk Management
Offered only in the Spring Semester.

<table>
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<th>CAS in Natural Hazard - Risk Management - Key for Type</th>
<th>Key for Hours</th>
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</tr>
<tr>
<td>W+ Eligible for credits and recommended</td>
<td>A independent project</td>
</tr>
<tr>
<td>W Eligible for credits</td>
<td>D diploma thesis</td>
</tr>
<tr>
<td></td>
<td>R revision course / private study</td>
</tr>
</tbody>
</table>

**Key for Hours**
- V lecture
- G lecture with exercise
- U exercise
- S seminar
- K colloquium

ECTS European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.

Special students and auditors need special permission from the lecturers.
## CAS in Nutrition for Disease Prevention and Health

### Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>M. B. Zimmermann</td>
</tr>
<tr>
<td>Abstract</td>
<td>To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.</td>
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<tr>
<td>Objective</td>
<td>To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.</td>
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<tr>
<td>Content</td>
<td>The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>There is no script. Powerpoint presentations will be made available on-line to students.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>No compulsory prerequisites, but prior completion of the courses &quot;Introduction to Nutritional Science&quot; and &quot;Advanced Topics in Nutritional Science&quot; is strongly advised.</td>
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</table>

| 752-6403-00L    | Nutrition and Performance            | W    | 2    | 2V    | S. Mettler, M. B. Zimmermann   |
| Abstract        | The course introduces basic concepts of the interaction between nutrition and exercise performance. |
| Objective       | To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise. |
| Content         | The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples. |
| Lecture notes   | Lecture slides and required handouts will be available on the ETH website (moodle). |
| Literature      | Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings. |
| Prerequisites / notice | General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition. |
| The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS). |

| 752-6301-00L    | Nutrition-Related Physiology         | W    | 3    | 2V    | F. von Meyenn, E. Gasser       |
| Abstract        | Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. |
| Objective       | Some basic knowledge in physiology is recommended for this course, which revisits important physiological topics, emphasizing their relation to nutrition. The aim is to give the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. For students with a background in medicine, pharmacy or biology, the course is useful as a review of previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance. |
| Lecture notes   | Handouts for each lecture will be uploaded to Moodle every week. |

### CAS in Nutrition for Disease Prevention and Health - Key for Type

- **O**: Compulsory
- **W+**: Eligible for credits and recommended
- **W**: Eligible for credits
- **E-**: Recommended, not eligible for credits
- **Z**: Courses outside the curriculum
- **Dr**: Suitable for doctorate

### Key for Hours

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium

- **P**: practical/laboratory course
- **A**: independent project
- **D**: diploma thesis
- **R**: revision course / private study

### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.

---

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 448 of 2345
# CAS in Nutrition in Medicine

## Modules

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<thead>
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<td>395-0300-00L</td>
<td>Introduction to Nutrition</td>
<td>O</td>
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<td>F. von Meyenn, I. Herter-Aeberli, J. Rigutto</td>
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<td>395-0301-00L</td>
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<td>Nutrition in Metabolic Disease</td>
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### CAS in Nutrition in Medicine - Key for Type

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<td>R</td>
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### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### CAS in Pharmaceuticals - From Research to Market

#### Modules

<table>
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<tr>
<th>Number</th>
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<td>541-0002-00L</td>
<td>Module 2: Project Management in the Pharmaceutical Industry</td>
<td>W</td>
<td>2.5 credits</td>
<td>3G</td>
<td>R. Schibli, R. Furegati Hafner</td>
</tr>
</tbody>
</table>

**Abstract**

The enrolment is done by the CAS in Pharmaceuticals study administration.

**Objective**

Project Management Basics:
- About projects, project management and the project environment
- How to define and plan my project, how to deal with stakeholders and how to manage project risks
- Managing my project team, developing the project plan and launching the project
- Managing my project team, developing the project plan and launching the project
- Monitoring and reporting, project close-out and project leadership
- Project evaluation and portfolio management
- Budget and resource management

**Workshop:**
- Development of a generic drug product in cross-functional project teams

**Communication:**
- Intercultural communication
- Negotiation skills
- Presentation power

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<td>541-0007-00L</td>
<td>Module 7: Clinical Development</td>
<td>W</td>
<td>2.5 credits</td>
<td>3G</td>
<td>R. Schibli</td>
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</tbody>
</table>

**Abstract**

The enrolment is done by the CAS in Pharmaceuticals study administration.

**Objective**

Module 7 gives an overview about the several steps that have to be followed during the process of clinical development.

- Preclinical bridge to clinical development
- Strategy for clinical development
- Regulatory aspects of clinical development
- Good clinical practice (GCP) and quality assurance
- First in human studies (Phase I), Proof of concept studies (Phase II), Registration studies (Phase III), Post-registration studies (Phase IV)
- Monitoring
- Organizational and financial aspects of clinical development
- Portfolio and life cycle management
- Data management and simulation of a clinical study
- Personalized medicine

#### Essay

<table>
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<td>R. Furegati Hafner, R. Schibli</td>
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</table>

**Abstract**

The enrolment is done by the CAS in Pharmaceuticals study administration.

**Objective**

The essay is an essential part of the CAS program „Pharmaceuticals – From Research to Market“ (CAS Pharm) and serves as final performance assessment.

**Literature**

www.postgraduate.pharma.ethz.ch documents: essay

#### CAS in Pharmaceuticals - From Research to Market - Key for Type

<table>
<thead>
<tr>
<th>O</th>
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#### Key for Hours

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Special students and auditors need special permission from the lecturers.
### Core Courses and Seminars

#### CAS in Preservation

*Only takes place every second autumn semester (even numbered years).*

<table>
<thead>
<tr>
<th>Number</th>
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<td>079-0100-00L</td>
<td>Seminar Basics</td>
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<td>S. Langenberg</td>
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**Abstract**
The seminar provides an introduction to the basics of scientific work. It imparts methods of architectural and cultural studies, introduces participants to archive-based research and enables them to critically and analytically evaluate the sources consulted. Forms of communicating scientific results are also a topic of the seminar.

**Objective**
The aim of the seminar is to qualify participants to apply methods of architectural and cultural studies in the evaluation of objects of the built environment. Participants are enabled to assess a building which they have selected in the form of a heritage conservation report. This lays the foundation for the second part, which deals with the independent scientific evaluation of a building which the participants choose individually.

**Content**
An essential basis for a responsible engagement with the built heritage is the ability to recognise its characteristics and peculiarities from an architectural scientific point of view, and to objectively elaborate on them. For this, knowledge of scientific methods is just as much a prerequisite as the ability to undertake purposeful research and to critically evaluate source material in order to productively include it in the analysis. The first part of the seminar is devoted to an introduction to scientific work in the fields of architectural and cultural studies. This

| 079-0101-00L | Seminar Texts on Preservation | O | 3 credits | 2S | R. Rehm, S. Langenberg |

**Abstract**
In the seminar, selected texts on architectural theory and monument preservation are read together and discussed in plenary. The focus is on selected writings from John Ruskin, Gottfried Semper and Friedrich Nietzsche to Alois Riegl and Adolf Loos to Walter Benjamin, Aleida Assmann and Peter Zumthor.

**Objective**
Skills in reading complex theoretical and literary writings on architecture and monument preservation are taught. With increasing practice, these enable participants to undertake an independent appropriation of architectural theory and monument preservation content.

**Content**
The writings on architectural theory and historic preservation discussed in the seminar provide an overview of the most important theories and concepts of historic preservation. Ruskin’s narrative of architectural historicity, Semper’s conception of “Bekleidung” and Nietzsche’s transformation of mythology are covered, as are Riegl’s notions of “Erinnerungswert” and “Gegenwartswert”, Loos’ writings on architecture, Benjamin’s notion of aura and Aleida Assmann’s memory space as well as Peter Zumthor’s atmosphere. Each text is discussed in terms of textual structure, conceptual history, visual language, relationship to poetry and literature, strategies of theory, etc. Identifying the levels and intersections that link a theory with other theories characterises one of the main tasks of our seminar.

**Literature**
- Georg Dehio, Kunsthistorische Aufsätze, Munich 1914.
- Uta Hassler/Winfried Nerdinger, Das Prinzip der Rekonstruktion, Zurich 2010.

| 063-0911-22L | Future Monuments | O | 2 credits | 2V | S. Langenberg |

**Abstract**
Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice.

**Objective**
In addition to active participation in the discussions, students will be asked to engage with a topic or object of their own choice in order to be able to develop and comprehensively justify their own positions within the context of preservation. Our goal here is to foster students’ communication skills and the culture of discussion.

**Content**
The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. This core conveys this knowledge to students with the help of selected writings and discusses them in the context of various guest lectures. In addition to dealing with historical buildings, the course is also dedicated to younger (and very young) objects and inventories - for in addition to the preservation of already listed objects, the selection and inventory of future protected objects is also one of the core tasks of heritage conservation.
Monographs and edited volumes:


Dehio, Georg, Kunsthistorische Aufsätze. München 1914


Franz, Birgit, Gerhard Vinken und Johanna Blokker (Hg.), Denkmal - Werte - Bewertung, Denkmalpflege im Spannungsfeld von Fachinstitution und bürgerschaftlichem Engagement, Holzminden 2013 (Veröffentlichung des Arbeitskreises Theorie und Lehre der Denkmalpflege e.V., Band 23).

Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohllieben, Marion und Georg Mörsch, Georg Dehio und Alois Riegl - Konserviren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:

Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008

Stadt Zürich Hochbaudepartement, Amt für Städtebau (Hg.), Bauten, Gärten und Anlagen 1960 bis 1980. Inventarergänzung, August 2013


Die Kunstdenkmäler der Schweiz

INSA – Inventare der Heimatkantone der Teilnehmenden
Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Theoretical Competencies</th>
<th>Taught competencies</th>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
<td>Techniques and Technologies</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<td>not assessed</td>
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</table>

Social Competencies

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

Personal Competencies

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

Major Courses and Cooperations

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<td>079-0150-00L</td>
<td>Preservation Law</td>
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<td>S. Langenberg</td>
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</table>

Abstract
The course elaborates the legal concept of “monument” in its important distinction from the respective scientific concept. It highlights its embeddedness and effect in public building law. Furthermore, it deals with legal protection instruments and procedures.

Objective
In addition to elaborating the legal concept of monuments, the course familiarises participants with legal protection instruments and procedures. It is planned to involve the participants by means of practical examples.

Content
The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a "monument"; structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with the procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer’s (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.

079-0151-00L | Theory and History of Preservation in the German-speaking Realm | O | 2 credits | 2V | external organisers |

Abstract
The course provides an overview of theory formation in heritage conservation. The focus is on European history and German-language texts.

Objective
The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation from antiquity to the 21st century, and to contrast the different approaches to thought and their development.

Content
In order to get to know the formation of theory, its paths and detours, the most important terms and persons in the history of monument conservation are introduced. Based on various texts, the history of the protection of architectural monuments since antiquity is illuminated. Further focal points in the history of monument preservation were during the Enlightenment, the French Revolution and in the process of the formation of nation states. The discourse on the concept and practice of monument conservation as we understand it today was led by a number of conservatives in the German-speaking world around 1900. War-related destruction and the incipient building boom in Europe led to modern debates on the theory of monuments, which are still relevant today. Dealing with monument values is not an end in itself; it can be essential for the preservation of the monument or for historical mediation. Critical positions on the tasks, goals or practices of heritage preservation can only be developed against the background of a knowledge of its historical approaches.

Literature
- Wolfgang Götz, Beiträge zur Vorgeschichte der Denkmalschutz. Die Entwicklung der Denkmalschutz in Deutschland vor 1800 (Diss. Leipzig 1956), Zurich 1999 (Veröffentlichungen des Instituts für Denkmalpflege an der ETH Zürich, vol. 20).
- Gottfried Kiesow, Einführung in die Denkmalschutz, Darmstadt 1982.
- Denkmalschutz. Texte zum Denkmalschutz und zur Denkmalspflege, Bonn 1996 (Schriftenreihe des Deutschen Nationalkomitees für Denkmalschutz, vol. 52).

Prerequisites / notice
To follow

CAS in Preservation - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |
### Key for Hours

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**ECTS**

European Credit Transfer and Accumulation System

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## CAS Thesis

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**Abstract**

In their CAS thesis, participants synthesize their learning and apply their insights to their own institutions or examine a relevant topic employing the course methodologies.

**Objective**

Practical application of course content and concepts.

**Taught competencies**

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**CAS in Public Governance and Administration - Key for Type**

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**ECTS**

European Credit Transfer and Accumulation System

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

**Module I: Pharmacy and Legislation**

- **Type:** O
- **ECTS:** 4 credits
- **Hours:** 6G
- **Lecturers:** R. Schibli

The enrolment is done by the CAS study administration.

**Abstract**

Knowledge of the fundamentals of development, preparation, testing and stability of sterile radiopharmaceutical preparations. Acquisition of basic information on European legislation in Radiopharmacy including GMP and Pharmacopoeia.

**Objective**

- Good manufacturing practice (GMP) of classical radiopharmaceuticals
- GMP: industrial point of view
- Molecular and cellular aspects of radiobiology
- Pharmacopoeia
- Pharmacopoeia – how to use it
- Design of dosage forms for pharmaceuticals
- Pharmaceutical packaging
- Methods of preparation of sterile products
- Aseptic preparation
- The role of excipients in parenteral radiopharmaceutical preparations
- Sterility testing and endotoxin determination
- Particulate contamination
- Principles of medicinal chemistry
- An overview of modern pharmaceutical analysis
- Genetic engineering
- Stability and shelf-life of pharmaceuticals
- (in)stability of radiopharmaceuticals
- Legislation in radiopharmacy
- European directives – GMP
- Specific radiopharmaceutical legislation
- Clinical trials directive and related documents
- The small scale, non-commercial preparation of radiopharmaceuticals
- GMP of PET radiopharmaceuticals
- Quality assurance and preparation of SOP
- Water for pharmaceutical use
- Practicals: visit to hospital radiopharmacy
- Basic concepts of pharmacokinetics
- Drug regulatory affairs
- Microbiology in Pharmacy
- Visit to pharmaceutical company

**Module III: Radiopharmacology and Clinical Radiopharmacy**

- **Type:** O
- **ECTS:** 4 credits
- **Hours:** 6G
- **Lecturers:** R. Schibli, R. Furegati Hafner

The enrolment is done by the CAS study administration.

**Abstract**

Knowledge about the fundamentals of pharmacokinetics and pharmacokinetic modelling, the basic concepts of pharmacology and toxicology, radiopharmaceutical monographs in the European pharmacopoeia, radiological imaging modalities and the basics of applied statistics in biomedical research. Understanding the fundamentals of nuclear medicine: Diagnostic applications in neurology and oncology therapy.

**Objective**

- Pharmakokinetics and kinetic-modelling
- Statistics and practical session
- Radiotracers in biochemistry and molecular pharmacology
- Selective modification of peptides and proteins to target GPCRs
- Demonstration of experimental set up: Peptide and protein modification, radioactive assays in biochemistry
- Visit ABX Radeberg
- Nuclear medicine: basics and therapy
- Immunology
- Drug interventions/interactions/adverse reactions
- Pharmacology basics, special aspects, clinical studies
- Toxicology
- Testsystems in toxicology and targeted therapeutics and nucleic acids
- Nuclear medicine: clinical diagnostic applications in neurology
- Nuclear medicine: visit to SPECT facility and radiopharmaceutical GMP lag (Tc, Ga, therapy)
- Radiological imaging modalities- technology and applications
- Nuclear medicine: clinical diagnostic applications in oncology
- Radiopharmaceutical monographs in the European pharmacopoeia
- Practical session, visit: cyclotron, GMP PET production and quality control, PET and PET/CT, therapy unit
- Radioligand-binding-assays/autoradiography
- In house tours in groups: radioligand-binding-assays, autoradiography, metabolite analytics with LC-MS, cyclotron and radiochemistry, highlights in Leipzig
- Biological effects of radiation
- Radiotracer transport and blood brain barrier
- Radiotracers for neuroimaging

### CAS in Radiopharmaceutical Chemistry, Radiopharmacy - Key for Type

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### CAS in Spatial Planning

#### Lectures

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<td>115-0510-00L</td>
<td>Lecture 10: Spatial Development</td>
<td>W</td>
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<td>M. Nollert, J. Van Wezemael</td>
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<tr>
<td>Abstract</td>
<td>In this course, the fundamental methods in spatial planning learned in the first week, in particular regarding planning methodology, spatial design and argumentation are consolidated in lectures and case studies.</td>
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<td>Objective</td>
<td>The aim of the lecture is the consolidation and the practice of important methodic principles in spatial planning. They provide a basis also for the work in the second Study Project of the MAS program.</td>
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<tr>
<td>115-0511-00L</td>
<td>Lecture 11: Urban Planning and Urban Design II</td>
<td>W</td>
<td>2</td>
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<td>S. Kretz, to be announced</td>
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<td>Abstract</td>
<td>The second week on urban design and urban planning focuses on a case study in the field of strategic urban design. The course includes lectures, discussions, methodological inputs and a design workshop. Students analyze and discuss a real life problem and elaborate proposals for a suitable urban design strategy.</td>
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<tr>
<td>Objective</td>
<td>The aim of the course is an in-depth understanding of contemporary urban design challenges and an exemplary, case-based experience of elaborating adequate urban design strategies.</td>
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<td>115-0512-00L</td>
<td>Lecture 12: Spatial Planning: Theory and Methodology</td>
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<td>2</td>
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<td>A. Voigt</td>
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<tr>
<td>Abstract</td>
<td>Impart thinking patterns and active application of fundaments of planning theories and methods. The main focus is on plausibility and rigor of reasoning in spatial planning, from problem definition and analysis of its causes to the formulation of robust solutions; development of different planning steps considering communication theory and ethical aspects.</td>
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<tr>
<td>Objective</td>
<td>Autonomous and productive application of analyzed thinking patterns and planning steps; situationally appropriate and task-oriented transfer to new planning problems.</td>
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<td>115-0513-00L</td>
<td>Lecture 13: Academic Working in Spatial Planning</td>
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<td>2</td>
<td>1G</td>
<td>R. Nebel, A. Rupf</td>
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<tr>
<td>Abstract</td>
<td>Understanding what scientific work means in spatial planning. Procedures for clarification processes; basics of scientific working and writing; case studies and exercises.</td>
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<td>Objective</td>
<td>Knowledge for a scientific way of working; structuring a scientific paper using the example of the DAS Synopsis or MAS Thesis.</td>
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<td>115-0514-00L</td>
<td>Lecture 14: Spatial Planning: International Aspects</td>
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<td>F. Persyn</td>
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<tr>
<td>Abstract</td>
<td>Introduction to international perspectives in spatial planning. Exploring various scales and their interconnectedness as well as flows and practices that bridge different cultures of planning. International competitions as a tool to navigate different planning realities, terrains and transformations. Team work on an ongoing case.</td>
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<tr>
<td>Objective</td>
<td>Learning from different spatial planning cultures, their interaction and improving the capacity to understand and bring solutions to diverse planning contexts.</td>
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**CAS in Spatial Planning - Key for Type**

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**Key for Hours**

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**ECTS** European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Regenerative Materials - Hygrothermal Specialisation

Offered only in the Autumn Semester.

### Module

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CAS in Regenerative Materials - Hygrothermal Specialisation - Key for Type

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Key for Hours

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ECTS European Credit Transfer and Accumulation System

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# CAS in Regulatory Thinking

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**Note:** Special students and auditors need special permission from the lecturers.
Abstract
In the CAS Robotics participants are offered a RobotX professor as a mentor together with whom they design their study plan along an individually-specified focus area in the area of Robotics and AI. Based on the individual expertise and interests of the participants, the customised Robotics and AI module consists of a combination of (i) research project, ii) lectures, (iii) knowledge transfer.

Objective
The CAS Robotics and AI module offers experienced industry individuals the opportunity to undergo research-related training in Robotics and AI, to update their knowledge and to expand their area of expertise in a targeted manner and aims at:
- training skills at the frontiers of the current state of research in Robotics and AI,
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

Special students and auditors need special permission from the lecturers.
## CAS in Seismic Evaluation and Retrofitting

Offered only in the Autumn Semester.

### Module

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<td>Module 1: Introduction to Seismic Design and Swiss Seismic Code Provisions only for CAS in Seismic Evaluation and Retrofitting.</td>
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<td>A. Tsiavos, B. Stojadinovic</td>
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<td>Abstract</td>
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<td>The objective of this Module is to introduce the principles of Seismic Design of Structures and the Swiss Seismic Code Provisions to Civil Engineers working in Switzerland.</td>
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<td>- To understand the critical points of the Swiss Code Provisions for the seismic design of new structures and the seismic evaluation of existing structures</td>
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<td>- To get an overview in the dynamics and the principles of seismic design of structures</td>
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<td></td>
<td>1.1 Introduction to seismic hazard and seismic risk, seismic performance objectives, common structural deficiencies and observed damage patterns due to earthquake ground motion excitation</td>
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<td>1.2 Seismic elastic and inelastic response of SDOF systems and earthquake response spectra</td>
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<td>1.3 Seismic elastic and inelastic response of MDOF systems, Response Spectrum Analysis and Pushover Analysis</td>
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<td>1.4 Seismic Design of structures using SIA 261: Presentation and Examples</td>
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<td>1.5 Good practices for the seismic design of new structures</td>
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<td>1.6 Seismic safety of non-structural components</td>
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<td>1.7 Swiss Code Provisions for the seismic evaluation of existing structures SIA 269/8: Presentation and examples, Evaluation of commensurability of seismic retrofitting measures</td>
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<tr>
<td></td>
<td>- Anwesenheit (mind. 80% pro Präsenzwoche) und aktive Mitarbeit in den Präsenzwochen</td>
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</tr>
<tr>
<td></td>
<td>- mindestens genügende Leistungen bei Leistungskontrollen</td>
<td></td>
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</tr>
<tr>
<td>139-0102-00L</td>
<td>Module 2: Finite Element Modelling and Identification of the Seismic Behavior of Structures only for CAS in Seismic Evaluation and Retrofitting.</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>A. Tsiavos, B. Stojadinovic</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- To use the state-of-the-art FEM software and implement the optimal FE modelling techniques for the simulation of the seismic response of existing buildings (concrete, masonry, mixed concrete-masonry) located in Switzerland</td>
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<tr>
<td></td>
<td>- To obtain knowledge of the FEM software and the modelling techniques for the simulation of soil-structure interaction</td>
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<tr>
<td></td>
<td>- To understand the current methodologies for the identification and monitoring of the vibration and the seismic behavior of structures located in Switzerland.</td>
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<tr>
<td>139-0103-00L</td>
<td>Module 3: Analysis Methods and Case Study Examples of Seismic Evaluation and Retrofitting only for CAS in Seismic Evaluation and Retrofitting.</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>A. Tsiavos, B. Stojadinovic</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>The scope of this Module is to present Analysis Methods and Case Study Examples that illustrate established procedures and practical engineering solutions that are applied in the seismic evaluation and retrofitting of existing structures by Civil Engineers working in Switzerland.</td>
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<tr>
<td></td>
<td>Objective</td>
<td></td>
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<tr>
<td></td>
<td>- To acquire practical knowledge of the seismic retrofitting techniques commonly used in Switzerland, their implementation and their cost</td>
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<td></td>
<td>- To select the appropriate analysis method for the seismic evaluation of structures located in Switzerland and understanding of the governing factors</td>
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<tr>
<td>139-0104-00L</td>
<td>Module 4: Individual Project Exercise only for CAS in Seismic Evaluation and Retrofitting.</td>
<td>O</td>
<td>4 credits</td>
<td>2P</td>
<td>A. Tsiavos, B. Stojadinovic</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>- To conduct independently a seismic evaluation of an existing structure located in Switzerland considering the boundary conditions that influence the seismic behavior of the structure</td>
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</tbody>
</table>

### CAS in Seismic Evaluation and Retrofitting - Key for Type

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

### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>R</td>
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</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Technologies substantially affect the way we live and how our societies function. Technological change, i.e. the innovation and diffusion of new technologies, is a fundamental driver of economic growth but can also have detrimental side effects. This module introduces methods to assess technology-related policy alternatives and to analyse how policies affect technological changes and society.

Objective
Participants understand (1) the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates, (2) why national economic activity fluctuates, (3) what economic policy can do against unemployment and inflation, (4) what significance international economic relations have for specific countries, such as Switzerland.

Literature
Course materials can be found on Moodle.

CAS in Technology and Public Policy: Impact Analysis
Offered only in Autumn Semester.

<table>
<thead>
<tr>
<th>Module</th>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
Markets play an important function in modern societies by allocating resources and capital. Yet, important market failures require the intervention of public policy. This module introduces the fundamentals of micro- and macro-economics and thereby lays the foundation for the economic assessment of policy interventions.

Objective
Participants (1) understand basic principles, problems and approaches in microeconomics, (2) can analyse and explain simple economic principles in a market using supply and demand graphs, (3) can contrast different market structures and describe firm and consumer behaviour, (4) can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole, (5) can address utility maximization and cost minimization problems.

How Markets Function (Microeconomics):
Participants understand (1) the role risk and uncertainty play in decision-making, (2) why ex ante and ex post policy impact analysis is, (2) in what forms and with what methods they can be undertaken, (3) why they are important for evidence-based policy-making.

Analysis of Policy and Technology Options:
Participants understand (1) how to perform policy analyses related to technology; (2) a policy problem and the rationale for policy intervention; (3) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (4) how to assess policy alternatives, using various ex ante policy analysis methods; (5) and how to communicate the results of the analysis.

Evaluation of Policy Outcomes:
Participants understand (1) when and why policy outcomes can be evaluated based on observational or experimental methods, (2) basic methods for evaluating policy outcomes (e.g. causal inference methods and field experiments), (3) how to apply concepts and methods of policy outcome evaluation to specific cases of interest.

Big Data Approaches to Policy Analysis:
Participants understand (1) why "big data" techniques for making policy-relevant assessments and predictions are useful, and under what conditions, (2) key techniques in this area, such as procuring big datasets; pre-processing and dimension reduction of massive datasets for tractable computation; machine learning for predicting outcomes; interpreting machine learning model predictions to understand what is going on inside the black box; data visualization including interactive web apps.

Literature
Course materials can be found on Moodle.

<table>
<thead>
<tr>
<th>Module</th>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>876-0201-00L</td>
<td>Technology and Policy Analysis</td>
<td>O</td>
<td>8 credits</td>
<td>5G</td>
<td>T. Schmidt</td>
<td></td>
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</tbody>
</table>

Abstract
Technologies substantially affect the way we live and how our societies function. Technological change, i.e. the innovation and diffusion of new technologies, is a fundamental driver of economic growth but can also have detrimental side effects. This module introduces methods to assess technology-related policy alternatives and to analyse how policies affect technological changes and society.

Objective
Introduction:
Participants understand (1) what ex ante and ex post policy impact analysis is, (2) in what forms and with what methods they can be undertaken, (3) why they are important for evidence-based policy-making.

Analysis of Policy and Technology Options:
Participants understand (1) how to perform policy analyses related to technology; (2) a policy problem and the rationale for policy intervention; (3) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (4) how to assess policy alternatives, using various ex ante policy analysis methods; (5) and how to communicate the results of the analysis.

Evaluation of Policy Outcomes:
Participants understand (1) when and why policy outcomes can be evaluated based on observational or experimental methods, (2) basic methods for evaluating policy outcomes (e.g. causal inference methods and field experiments), (3) how to apply concepts and methods of policy outcome evaluation to specific cases of interest.

Big Data Approaches to Policy Analysis:
Participants understand (1) why "big data" techniques for making policy-relevant assessments and predictions are useful, and under what conditions, (2) key techniques in this area, such as procuring big datasets; pre-processing and dimension reduction of massive datasets for tractable computation; machine learning for predicting outcomes; interpreting machine learning model predictions to understand what is going on inside the black box; data visualization including interactive web apps.

Literature
Course materials can be found on Moodle.

<table>
<thead>
<tr>
<th>Module</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>876-0301-00L</td>
<td>Policy-Making in Practice</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>T. Bernauer, D. N. Bresch, T. Schmidt</td>
<td></td>
</tr>
</tbody>
</table>

Abstract
Effective management of risks and uncertainty as well as communication of scientific evidence to stakeholders and policy-makers are essential for successful policy-advise and policy-making. Hence, this module conveys the fundamentals of risk analysis/management and of writing for policy-makers. Besides an academic perspective, it features practitioners working at the technology-policy interface.

Objective
Participants understand (1) the role risk and uncertainty play in decision- and policy-making, (2) common approaches to risk management, (3) how to apply methods of quantitative risk analysis, (4) how to communicate risk information clearly and effectively.

Writing for-Policy-Makers:
Participants understand (1) particular prerequisites for successful dissemination of scientific results to policy-makers and the wider public, (2) expectations and needs of different target groups and audiences, (3) how to effectively write policy briefs for stakeholders and policy-makers.

Literature
Course materials can be found on Moodle.

CAS in Technology and Public Policy: Impact Analysis - Key for Type

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

Key for Hours
- V lecture
- G lecture with exercise
- U exercise
- S seminar
- K colloquium
- P practical/laboratory course
- A independent project
- D diploma thesis
- R revision course / private study

European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
## CAS in Transport Engineering

### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>149-0001-00L</td>
<td>Transport Planning - Theory and Models</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>K. W. Axhausen</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td></td>
<td>Only for CAS in Transport Engineering and MAS in Future Transport Systems</td>
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<tr>
<td>149-0002-00L</td>
<td>Traffic Engineering</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td></td>
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<tr>
<td></td>
<td>Only for CAS in Transport Engineering and MAS in Future Transport Systems</td>
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### CAS in Transport Engineering - Key for Type

<table>
<thead>
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<th>O</th>
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<tbody>
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<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
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</tr>
</thead>
<tbody>
<tr>
<td>G</td>
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<tr>
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</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Chemistry (General Courses)

► General Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0073-00L</td>
<td>Radiochemistry</td>
<td>Z</td>
<td>2 credits</td>
<td>2V</td>
<td>to be announced</td>
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<tr>
<td>Abstract</td>
<td>Principles and phenomena around radioactivity.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Knowledge of the most important phenomena in relation with radioactivity. Knowledge of the principles of radiation protection. Ability to judge dangerous situations in handling radioactive materials, geopolitically as well as locally at ones own working place.</td>
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</tr>
<tr>
<td>Content</td>
<td>Structure and properties of atomic nuclei, mathematical description of the radioactive decay, decay types, interaction of radiation with matter, detectors for ionizing radiation, radiation protection, principles of isotope separation, nuclear power plants, major nuclear accidents. Additional topics may be suggested by the students.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>A script is available free of charge.</td>
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<tr>
<td></td>
<td>Weitere Literaturangaben werden nach Bedarf in der Vorlesung abgegeben.</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Institute-Seminar covering current research Topics in Physical Chemistry</td>
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</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0688-00L</td>
<td>Safety Lecture for Assistants</td>
<td>Z</td>
<td>0 credits</td>
<td></td>
<td>T. Mäder</td>
</tr>
<tr>
<td>Abstract</td>
<td>Safety-Praxis und Riskmanagement in Laboratorien</td>
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</tr>
<tr>
<td>Objective</td>
<td>Gute Safety-Praxis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Safety-Regeln, Riskmanagement im Labor, Safety-Parcours</td>
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</tbody>
</table>

Chemistry (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Key for Hours</th>
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</thead>
<tbody>
<tr>
<td>V lecture</td>
</tr>
<tr>
<td>G lecture with exercise</td>
</tr>
<tr>
<td>U exercise</td>
</tr>
<tr>
<td>S seminar</td>
</tr>
<tr>
<td>K colloquium</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

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## Chemistry Bachelor

### 1. Semester

#### Compulsory Subjects First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-02L</td>
<td>General Chemistry (inorganic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.</td>
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</tr>
</tbody>
</table>

| 529-0011-03L    | General Chemistry (organic Chemistry) I           | O    | 3    | 2V+1U | P. Chen     |
| **Abstract**    | Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions. |
| **Objective**   | Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicality, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intermolecular interactions. |
| **Content**     | Subject-specific Competencies |
| **Taught competencies** | Concepts and Theories | assessed |
| **Method-specific Competencies** | Techniques and Technologies | assessed |
| **Social Competencies** | Analytical Competencies | assessed |
| **Communication** | Decision-making | assessed |
| **Leadership and Responsibility** | Media and Digital Technologies | not assessed |
| **Self-presentation and Social Influence** | Problem-solving | assessed |
| **Negotiation** | Project Management | not assessed |
| **Personal Competencies** | Adaptable and Flexibility | not assessed |
| **Adaptability and Flexibility** | Creative Thinking | not assessed |
| **Critical Thinking** | Media and Digital Technologies | assessed |
| **Integrity and Work Ethics** | Self-awareness and Self-reflection | assessed |
| **Self-awareness and Self-reflection** | Self-direction and Self-management | assessed |
| **Lecture notes** | Underlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt |

| 529-0011-01L    | General Chemistry (physical Chemistry) I          | O    | 3    | 2V+1U | H. J. Wörner |
| **Abstract**    | The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding. |
| **Objective**   | After the lecture, students will be able to, |
| **Content**     | - to calculate physical quantities and their units which are important for chemistry, |
| **Lecture notes** | - to name some properties of chemically relevant particles and propose experimental methods to determine these properties, |
| **Literature**  | - to name applications and hazards of radioactivity, |
| **Method-specific Competencies** | - to categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them, |
| **Social Competencies** | - to describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection, |
| **Communication** | - to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them, |
| **Leadership and Responsibility** | - to analyze and calculate absorption and emission spectra of single-electron atoms, |
| **Self-presentation and Social Influence** | - to set up the Schrödinger equation for a molecular multi-particle system, |
| **Negotiation** | - independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems, |
| **Personal Competencies** | - model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model, |
| **Adaptable and Flexibility** | - explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom, |
| **Critical Thinking** | - explain the structure of the periodic table of elements with the help of the orbital concept, |
| **Integrity and Work Ethics** | - recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and |
| **Self-awareness and Self-reflection** | - establish term symbols for atomic ground states, |
| **Self-direction and Self-management** | Translated with www.DeepL.com/Translator (free version) |
| **Literature**  | Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung, |

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 466 of 2345
Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company

Lecture notes
The lecture follows the book "Physics" by Paul A. Tipler.

Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag
R. Sperb/M. Akveld: Analysis I (vdf)
L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

Further reading suggestions will be indicated during the lecture.

Mathematical Foundations I: Analysis A

Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag
R. Sperb/M. Akveld: Analysis I (vdf)
L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

For more information about the lecture: www.csms.ethz.ch/education/InfoI

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/InfoI

Introduction to Computer Science

Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation; Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.

See: www.csms.ethz.ch/education/InfoI

Laboratory Courses

Prerequisites / notice
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/InfoI

Latest online enrolment is 19.09.2022

Information about the practical course will be given on the first day.

Qualitative analysis (determination of cations and anions), acid-base-equilibria (pH-values, titrations, buffer), precipitation equilibria (gravimetry, potentiometry, conductivity), redox reactions (syntheses, redox-titrations, galvanic elements), metal complexes (syntheses, complexometric titration), Analysis of measured data, vapour pressure, conductivity, calorimetry, solubility.
Objective

Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation state and redox behaviour (syntheses), redox-titrations, galvanic elements, metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration)

analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimetry, solubility).

Content

The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their state of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes

http://www.gruetzmacher.ethz.ch/education/labcourses

Literature


Moodle Lernplattform

Prerequisites / notice

Compulsory: online enrolment latest one week after start of the semester

Safety conceptt: https://chab.ethz.ch/studiam/bachelor1.html

3. Semester

Compulsory Subjects Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<tr>
<td>529-0121-00L</td>
<td>Inorganic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. Grützmacher, P. Steinegger</td>
</tr>
</tbody>
</table>

Abstract

Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals as well as the lanthanides and actinides. Introduction of methods of characterization, physical-chemical properties of coordination compounds as well as principles of radiochemistry.

Objective

The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. The students will acquire knowledge on the fundamentals of radioactive decay and radiochemistry. Furthermore, they will be familiar with the basics of inorganic chemistry of lanthanides and actinides.

Content

This course consists of the following parts, which introduce the students to the chemistry of transition metals as well as lanthanides and actinides: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) Properties and characterization of coordination compounds; 9) Introduction to radiochemistry; 10) Principles of the chemistry of the lanthanides and actinides.

Lecture notes

Eine kommentierte Foliensammlung ist im HCI-Shop erhältlich.

Literature


Taught competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Organic Chemistry I

This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

Objective

The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.

Content


Lecture notes

The lecture slides, problem sets, and additional documents are provided online. Link: https://wennewers.ethz.ch/education.html

Literature


Physical Chemistry II: Chemical Reaction Kinetics

**Objective**
Introduction to Chemical Reaction Kinetics

**Content**

**Lecture notes**
Will be provided

**Literature**

**Prerequisites / notice**

**529-0051-00L Analytical Chemistry I**

**Abstract**
Introduction into the most important spectroscopical methods and their applications to gain structural information.

**Objective**
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

**Content**
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

**Lecture notes**
Script will be for the production price

**Literature**
- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

**Prerequisites / notice**
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

**401-0373-00L Mathematics III: Partial Differential Equations**

**Abstract**

**Objective**
Classical tools to solve the most common linear partial differential equations.

**Content**
1) Examples of partial differential equations
   - Classification of PDEs
   - Superposition principle

2) One-dimensional wave equation
   - D'Alembert's formula
   - Duhamel's principle

3) Fourier series
   - Representation of piecewise continuous functions via Fourier series
   - Examples and applications

4) Separation of variables
   - Solution of wave and heat equation
   - Homogeneous and inhomogeneous boundary conditions
   - Dirichlet and Neumann boundary conditions

5) Laplace equation
   - Solution of Laplace's equation on the rectangle, disk and annulus
   - Poisson formula
   - Mean value theorem and maximum principle

6) Fourier transform
   - Derivation and definition
   - Inverse Fourier transformation and inversion formula
   - Interpretation and properties of the Fourier transform
   - Solution of the heat equation

7) Laplace transform (if time allows)
   - Definition, motivation and properties
   - Inverse Laplace transform of rational functions
   - Application to ordinary differential equations

**Lecture notes**
See the course web site (linked under Lernmaterialien)


Additional books:


4) E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1, 2, 11, 12, 6)

For additional sources, see the course web site (linked under Lernmaterialien)

Prerequisites / notice

1) Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant

2) Multiple integrals: Riemann integrals in two or three variables, change of variables

2) Sequences and series of numbers and of functions

3) Basic knowledge of ordinary differential equations

Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-0129-00L</td>
<td>Inorganic and Organic Chemistry II</td>
<td>O</td>
<td>11 credits</td>
<td>16P</td>
<td>V. Mougel</td>
</tr>
</tbody>
</table>

Abstract

Introduction to the experimental methods of Inorganic Chemistry

Objective

The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a main topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques.

Content

Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Lecture notes

A manual is distributed in the teaching laboratory.

Prerequisites / notice

- Passed Basisprüfung
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)
- Continuous Attendance of Course Inorg. Chemistry 1 (3. Sem., 529-0121) and Analytical Chemistry 1 (3. Sem., 529-0051)

If necessary, access priority will be settled according to the results of the first-year examinations.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

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

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

5. Semester

Compulsory Subjects Examination Block II

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<tr>
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<tr>
<td>529-0132-00L</td>
<td>Inorganic Chemistry III: Organometallic Chemistry and O Homogeneous Catalysis</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Bezdek, C. Copéret</td>
</tr>
</tbody>
</table>

Abstract

Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbonylation, C-C bond-forming and related reactions.
Organic Chemistry III: Introduction to Asymmetric Synthesis

Abstract: Methods of Asymmetric Synthesis

Objective: Understanding the basic principles of diastereoselective synthesis

Content: Conformational analysis: acyclic and cyclic systems; Diastereoselective sigmatropic rearrangements; Diastereoselective Carbonyl addition reactions; Cram- and Felkin-Anh models, carbonyl Lewis acid interactions, chelate controlled reactions; chemistry of enolates, selective formation; asymmetric enolate alkylation; aldol reactions, allyl- and crotyl-metal chemistry; cyclisations, Baldwin rules; Diastereoselective olefin functionalization: hydroboration, dihydroxylation, epoxidation.


Taught competencies

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

529-0432-00L Physical Chemistry IV: Magnetic Resonance

Abstract: Theoretical foundations of magnetic resonance (NMR, EPR) and selected applications. Introduction to magnetic resonance in isotropic and anisotropic phase.

Objective: The course gives an introduction to magnetic resonance spectroscopy (NMR and EPR) in liquid, liquid crystalline and solid phase. It starts from a classical description in the framework of the Bloch equations. The implications of chemical exchange are studied and two-dimensional exchange spectroscopy is introduced. An introduction to Fourier spectroscopy in one and two dimensions is given and simple 'pulse trickery' is described. A quantum-mechanical description of magnetic resonance experiments is introduced and the spin Hamiltonian is derived. The chemical shift term as well as the scalar, dipolar and quadrupolar terms are discussed. The product-operator formalism is introduced and various experiments are described, e.g. polarization transfer. Applications in chemistry, biology, physics and medicine, e.g. determination of 3D molecular structure of dissolved molecules, determination of the structure of paramagnetic compounds and imaging (MRI) are presented.

Lecture notes: handed out in the lecture (in english)

Literature: see http://www.ssnmr.ethz.ch/education/PC_IV_Lecture

Laboratory Courses

Number Title Type ECTS Hours Lecturers
529-0449-00L Spectroscopy O 13 credits 13P E. C. Meister, B. Hattendorf

Abstract: Laboratory experiments to acquire a profound knowledge of spectroscopical methods and techniques in chemistry. Evaluation and visualization of measurement data. Writing lab reports.

Objective: Laboratory experiments to acquire a profound knowledge of spectroscopical methods and techniques in chemistry. Evaluation and visualization of measurement data. Writing lab reports.

Content: Laboratory experiments: UV/VIS spectroscopy, luminescence spectroscopy, FT infrared spectroscopy, light diffraction and refraction, thermal lenses, Raman spectroscopy, reflection spectroscopy, optical polarization phenomena, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), FT nuclear magnetic resonance spectroscopy (NMR), electron paramagnetic resonance spectroscopy (EPR), atomic force microscopy (AFM), Fourier transform methods.

Lecture notes: Detailed documentations to each experiment will be handed out.


Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Electives

Students are free to choose from a range of D-CHAB chemistry courses appropriate to their level of study (please note admission requirements). In case of doubt, contact the student administration.

Inorganic Chemistry

Number Title Type ECTS Hours Lecturers
529-0141-00L Physical Methods for Inorganic Chemistry W 6 credits 3G M. D. Wörle, D. Günther, J. Koch, R. Verel

Abstract: Introduction into the important methods for structural analysis (solid state NMR), crystal structure analysis and surface analysis techniques and their applications.
Physical Chemistry

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<tr>
<td>529-0441-00L</td>
<td>Signal Processing</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>F. Merkt, U. Hollenstein</td>
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<tr>
<td>Objective</td>
<td>Basics of signal processing in spectroscopy</td>
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Analytical Chemistry

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<tr>
<td>529-0041-00L</td>
<td>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano</td>
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<tr>
<td>Abstract</td>
<td>Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.</td>
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<tr>
<td>Objective</td>
<td>Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.</td>
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<tr>
<td>Content</td>
<td>Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).</td>
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<td>Literature</td>
<td>Information about relevant literature will be available in the lecture &amp; in the lecture notes.</td>
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<td>Prerequisites / notice</td>
<td>Exercises are an integral part of the lecture. Prerequisites: 529-0051-00 &quot;Analytische Chemie I (3. Semester)&quot; 529-0058-00 &quot;Analytische Chemie II (4. Semester)&quot; (or equivalent)</td>
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Biological Chemistry

<table>
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<tr>
<th>Number</th>
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<tr>
<td>529-0240-00L</td>
<td>Chemical Biology - Peptides</td>
<td>W</td>
<td>6</td>
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<td>H. Wennemers</td>
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<tr>
<td>Abstract</td>
<td>An advanced course on the synthesis, properties and function of peptides in chemistry and biology.</td>
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<tr>
<td>Objective</td>
<td>Knowledge of the synthesis, properties and function of peptides in chemistry and biology.</td>
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<tr>
<td>Content</td>
<td>Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.</td>
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<tr>
<td>Literature</td>
<td>Citations from the original literature relevant to the individual lectures will be assigned weekly.</td>
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<td>Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.</td>
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<tr>
<td>Abstract</td>
<td>Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines</td>
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<td>Objective</td>
<td>Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 472 of 2345
Content
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombiant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Taught competencies

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

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Problem-solving: assessed

- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: assessed

- Personal Competencies
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: assessed

### Chemical Aspects of Energy

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>529-0659-00L</td>
<td>Electrochemistry: Fundamentals, Cells &amp; Applications</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>L. Gubler</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.

**Objective**
The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of materials science and engineering and how they are put to use in selected applications.

**Content**
- Introduction: important quantities & units, terminology;
- Chapter I - Redox reactions, Faraday's laws;
- Chapter II - Equilibrium electrochemistry: cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces: electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes: conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry: overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry: electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion: important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors: potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion: corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

**Lecture notes**
lecture notes, exercise & solutions (PDF files) via download website

**Literature**

**Prerequisites / notice**
Students should be familiar with the fundamentals of physical chemistry.

### Chemical Crystallography

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0039-00L</td>
<td>Principles of Crystal Structure Determination</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>M. D. Wörle, N. Trapp</td>
</tr>
</tbody>
</table>

**Abstract**
An introduction to the principles of X-ray diffraction and crystal structure determination as it relates to Chemistry

**Objective**
To gain an understanding of the principles of crystal structure determination by X-ray diffraction.

**Content**
Basic crystallographic concepts: Unit cells, Bravais lattices, Laue symmetry, crystal classes (point groups), space groups, crystal growth, instrumentation, diffraction of X-rays by crystals: physical and geometric basics, powder and single crystal methods, structure solution and modelling, interpretation of crystal structure data; internal coordinates for structure description: atom spacing, co-ordination polyhedra, bond angles, torsion angles; intermolecular interactions, absolute configuration determination. Overview of inorganic, organic and macromolecular databases.

**Lecture notes**
The script and exercises will be distributed weekly in loose form
Literature

Main reference


Additional literature

(2) J.D. Dunitz, "X-ray Analysis and the Structure of Organic Molecules", 1995, Verlag HCA.


Computational Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0002-00L</td>
<td>Algorithms and Programming for Chemistry</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>S. Riniker, G. Landrum</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to algorithms (special focus on chemistry): Design of algorithms, data structures, search and sort algorithms, graphs, numerical algorithms, algorithms in cheminformatics, machine learning and bioinformatics Computer language: C++</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Development of programming skills and craftsmanship in order to be able to deal with the complexity of computer applications in chemistry. Introduction to algorithms (special focus on chemistry): Design of algorithms, data structures, search and sort algorithms, graphs, numerical algorithms, algorithms in cheminformatics, machine learning and cheminformatics Computer language: C++</td>
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<tr>
<td>Content</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Script (in English) will be available</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Since the exercises on the computer do convey and test essentially different skills as those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam.</td>
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</table>

Materials Science

Offered during Spring Semester.

Environmental Chemistry

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0037-01L</td>
<td>Introduction to Environmental Chemistry and Ecotoxicology</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>J. Hollender, T. Hofstetter, C. S. McArdell</td>
</tr>
<tr>
<td>Abstract</td>
<td>Anthropogenic activities related to production, use and disposal of goods cause emission of chemicals to the environment. This lecture provides an introduction to the knowledge required for assessing the risk of chemicals to human and environmental health by covering partitioning, reactivity, and toxic effects of chemicals as well as selected aspects of contemporary chemical analyses.</td>
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<tr>
<td>Objective</td>
<td>Students will develop a basic understanding for fate and effects of chemicals in the environment and learn how to use simple quantitative tools for the assessment of chemical behaviour and toxic effects.</td>
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<tr>
<td>Content</td>
<td>Part 1: Partitioning and reactivity * Physico-chemical description of partition behaviour of organic compounds * Partitioning in environmental media including soil/sediment, air, water * Chemical and biological transformations</td>
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<tr>
<td>Part 2: Effects</td>
<td>* Test systems for the assessment of ecotoxicological effects of chemicals * Bioavailability and bioaccumulation * Metabolism of organic compounds * Molecular mechanisms of toxic action</td>
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<tr>
<td>Part 3: Analyses</td>
<td>* Analytical methods for quantification of substances in water, soil, and air * Sampling, sample preparation and quantification of organic compounds in environmental media</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts/lecture slides will be made available electronically</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies Concepts and Theories assessed Techniques and Technologies assessed Critical Thinking assessed</td>
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Stratospheric Chemistry

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<tr>
<td>701-1233-00L</td>
<td>Stratospheric Chemistry</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>T. Peter, G. Chiado</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture gives an overview on the manifold reactions which occur in the gas phase, in stratospheric aerosol droplets and in polar cloud particles. The focus is on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.</td>
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</tbody>
</table>
Objective

The students will understand the gas phase reactions in the stratosphere as well as reactions and processes in aerosol droplets and polar stratospheric clouds.
The students will understand the most important aspects of stratospheric dynamics and the greenhouse gas effect in troposphere and stratosphere.
The students will also acquire a good understanding of the coupling between stratospheric ozone and climate change.
Furthermore, they will practise to explain fundamental concepts in stratospheric chemistry by means of scientific paper presentations.

Content

Short presentation of thermodynamical and kinetic basics of chemical reactions: bi- and termolecular reactions, photo-dissociation.
Introduction to the chemical family concept: active species, their source gases and reservoir gases. Detailed treatment of the pure oxygen family (odd oxygen) according to the Chapman chemistry. Radical reactions of the oxygen species with nitric oxide, active halogens (chlorine and bromine) and odd hydrogen. Ozone depletion cycles. Methane depletion and ozone production in the lower stratosphere (photo-smog reactions). Heterogeneous chemistry on the background aerosol and its significance for heavy air traffic. Chemistry and dynamics of the ozone hole: Formation of polar stratospheric clouds and chlorine activation.

Lecture notes

Documents are provided in the contact hours.

Literature


Prerequisites / notice

Prerequisites: Basics in physical chemistry are required and an overview equivalent to the bachelor course in atmospheric chemistry (lecture 701-0471-01) is expected.

701-1233-00 V starts in the first week of the semester. The exercises 701-1233-00 U will start only in the 2nd week of the semester.

Economics

<table>
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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceiçao Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
</tr>
</tbody>
</table>

Abstract

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
(1) broaden understanding of management principles and frameworks
(2) advance insights into the sources of corporate and entrepreneurial success
(3) develop skills to apply this knowledge to real-life managerial problems

Content

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

Prerequisites

Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Exercise) 351-0778-01.

Lecture notes

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work. The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

Lecturers

B. Clarysse, S. Brusoni, F. Da Conceiçao Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe

Science in Perspective

See Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MTEC

Language Courses

See Science in Perspective: Language Courses ETH/UZH

Chemistry Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Compulsory</th>
<th>Eligible for credits and recommended</th>
<th>Eligible for credits</th>
<th>Recommended, not eligible for credits</th>
<th>Courses outside the curriculum</th>
<th>Suitable for doctorate</th>
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<td>O</td>
<td>W+</td>
<td>W</td>
<td>E-</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 475 of 2345
### Key for Hours

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

**ECTS**

- European Credit Transfer and Accumulation System

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

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0242-06L</td>
<td>Cognitive Activating Instructions in MINT Subjects ■ W</td>
<td></td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
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<tr>
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<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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</tbody>
</table>

Abstract
This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get recent information about learning and instruction

Prerequisites / notice
Für eine reibungslose Semesterplanung wird um frühzeitige Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0242-07L</td>
<td>Human Intelligence ■ W</td>
<td></td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
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<tr>
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<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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</tbody>
</table>

Abstract
The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It will be required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

Objective
- Understanding research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science ■ W</td>
<td></td>
<td>1</td>
<td>2S</td>
<td>C. M. Thurn, T. Braas,</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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</tbody>
</table>

Abstract
Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0242-11L</td>
<td>Gender Issues in Education and STEM ■ W</td>
<td></td>
<td>2</td>
<td>2S</td>
<td>M. Berkowitz Biran, T. Braas,</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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</tbody>
</table>

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

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

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

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

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW 1).

Subject Didactics in Chemistry

Important Notice: Enrolment in the courses of this category is only possible if no more than 12 CP of potential additional requirements have to be acquired.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0959-00L</td>
<td>Mentored Work Subject Didactics Chemistry A ■</td>
<td></td>
<td>2</td>
<td>4A</td>
<td>A. Baertsch</td>
</tr>
</tbody>
</table>
Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt. In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

### Content

Thematische Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht. (Lernformen)


### Literature

Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt. Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt. Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

---

### Professional Training in Chemistry

*Important Notice: Enrolment in the courses of this category is only possible if no more than 12 CP of potential additional requirements have to be acquired.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
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<td>Mentored Work Subject Didactics Chemistry B</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>A. Baertsch</td>
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<tr>
<td></td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.</td>
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<tr>
<td></td>
<td>The objective is for the students: - to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too. - to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.</td>
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<tr>
<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Thematic Schwerpunkte</td>
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<tr>
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<td>Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht. (Lernformen)</td>
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<tr>
<td></td>
<td>Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt. Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt. Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.</td>
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### Professional Training in Chemistry

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<table>
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<tr>
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<td>4</td>
<td>3G</td>
<td>A. Baertsch</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in Introductory Internship Chemistry - course 529-0966-00L - is compulsory.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Implementing findings from research into teaching and learning for chemistry lessons and coverage of subject-specific teaching and learning specialities.</td>
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<tr>
<td></td>
<td>Objective</td>
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</tr>
<tr>
<td></td>
<td>The students have basic subject didactic knowledge for teaching chemistry at a secondary school. They are able to design lessons that are effective for learning, actively involve students in lessons, explain challenging concepts simply, use experiments for theory and reflect on teaching.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thematische Schwerpunkte</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Die Unterrichtsinhalte sind aus den Lernplattformen <a href="http://didchemie.pbworks.com">http://didchemie.pbworks.com</a> zugänglich</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E. Rossa: Chemie-Didaktik, Cornelsen Verlag, 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>H.-J. Bader et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>529-0964-00L</th>
<th>Teaching Internship Chemistry</th>
<th>O</th>
<th>8 credits</th>
<th>17P</th>
<th>A. Baertsch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching. They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils. They acquire the skills of the teaching trade. They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution. They learn to assess pupils’ work. Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>529-0955-00L</th>
<th>Professional Exercises: Experiments in Teaching Chemistry</th>
<th>O</th>
<th>2 credits</th>
<th>4V</th>
<th>A. Baertsch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Students can develop their own experiments. They can demonstrate experiments safely and convincingly, explain observations in a level-appropriate manner, use experiments to support theory, know why experiments need to be tested before demonstration, know some standard experiments, develop own experiments.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Schwerpunkte bilden die folgenden Themen: Theoretische Einführung, Merkmale für ein sicheres Experimentieren, Studierende erproben und demonstrieren bereitstehende Experimente, Experimente mit einer Skizze festhalten, Auf Basis der Literatur ein Experiment selbständig ausarbeiten, dokumentieren und vorführen, Experimente in den Unterricht einbetten, Aufgaben zur Auswertung entwerfen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Die Unterlagen und die im Kurs erarbeiteten Experimente sind auf <a href="http://fdchemie.pbworks.com">http://fdchemie.pbworks.com</a> zugänglich.</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>529-0968-00L</th>
<th>Examination Lesson I Chemistry</th>
<th>O</th>
<th>1 credit</th>
<th>2P</th>
<th>A. Baertsch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>On the basis of a specified topic, the candidate shows that they are in a position to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle. They analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.</td>
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</tbody>
</table>

Wird von der Praktikumslehrperson bestimmt. Das Einführungspraktikum findet an einem Gymnasium der Deutschschweiz statt.


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0962-00L</td>
<td>Fundamental Aspects of Chemistry with an Educational Focus B</td>
<td>4 credits</td>
<td>2V</td>
<td>A. Togni, R. Alberto</td>
<td></td>
</tr>
<tr>
<td>529-0968-02L</td>
<td>Examination Lesson II Chemistry ■ Simultaneous enrolment in “Examination Lesson I Chemistry” (529-0968-01L) is compulsory.</td>
<td>O 1 credit 2P</td>
<td>A. Baertsch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Abstract**

In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

**Content**

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

- To try out different options for specialist further training in their profession.
- To develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle.
- To analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.
- To try out different options for specialist further training in their profession.
- To independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readers.

**Lecture notes**

Dokument: Schriftliche Vorbereitung für Prüfungslektionen.https://www.ethz.ch/content/dam/ethz/main/education/didaktische-ausbildung/Files/Diverses/schriftliche%20Unterrichtsvorb%20%20%C3%Bcr%C3%BCftekt_04.11.2014..pdf

**Prerequisites / notice**

Nach Abschluss der übrigen Ausbildung.
**Thematische Schwerpunkte:**

**Lernformen:**

**Lecture notes**
Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

**Literature**
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt. Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

**Prerequisites / notice**
Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

---

**Chemistry Teaching Diploma - Key for Type**

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

**Key for Hours**

| V   | lecture                               | P  | practical/laboratory course          |
| G   | lecture with exercise                 | A  | independent project                  |
| U   | exercise                              | D  | diploma thesis                       |
| S   | seminar                               | R  | revision course / private study       |
| K   | colloquium                            |    |                                       |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Organic Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0233-01L</td>
<td>Organic Synthesis: Methods and Strategies</td>
<td>W+</td>
<td>6 credits</td>
<td>3G</td>
<td>E. M. Carreira</td>
</tr>
</tbody>
</table>

**Abstract**
The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

**Objective**

**Content**
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Literature**

**Prerequisites / notice**
OC I-IV

**Taught competencies**

<table>
<thead>
<tr>
<th>Competency</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<tr>
<td>Negotiation</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td></td>
</tr>
<tr>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

## Physical Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0433-01L</td>
<td>Advanced Physical Chemistry: Statistical Thermodynamics</td>
<td>W+</td>
<td>6 credits</td>
<td>3G</td>
<td>R. Riek, J. Richardson</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.


See homepage of the lecture.

Chemical Thermodynamics, Reaction Kinetics, Molecular Quantum Mechanics and Spectroscopy; Mathematical Foundations (Analysis, Combinatorial Relations, Integral and Differential Calculus)

See homepage of the lecture.

In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.

Students are accustomed to scientific work and they get to know one specific research field.

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Students are accustomed to scientific work and they get to know one specific research field.

In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.

Students are accustomed to scientific work and they get to know one specific research field.

Advanced laboratory course or internship depending on lab course Biological Chemistry B Candidates must inquire with P. Kast no later than September 1st whether course will take place (no self-enrollment)

All technologies used for the experiments will be explained to the students in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

This class conducts and supports experiments for a specifically designed genuine research project. We will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The relevant technologies will be taught to the students, such as the preparation of competent cells, production and isolation of DNA fragments, transformation of gene libraries, and DNA sequencing. The course participants will generate a variety of different variants of a chimeric mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The students will present the results obtained from their individual evolution experiments at the end of the semester. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalyst.

The necessary documents and protocols will be distributed to the participants during the course.

General literature to "Directed Evolution" and chimerate mutases, e.g.:


Further literature will be indicated in the distributed script.

- This laboratory course will involve experiments that require a tight schedule and (sometimes) long (!) working days.
- The projects of this course are tightly linked to the ones of the Biology BSc course "529-0739-01 Biological Chemistry B: New Enzymes from Directed Evolution Experiments", which takes place as a block course during the month of November. There will be joint lectures for the participants of both courses during that time. The teaching language is English.
- The number of participants for the laboratory course is limited. It is mandatory to sign up for the course directly with P. Kast no later than September 1, prior to the start of the fall semester. Until then it will be decided whether the course will take place.
- A valid registration is considered a commitment for attendance of the entire semester course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast.
- For more information, see also http://www.kast.chem.ethz.ch/teaching.html or contact P. Kast directly (HCI F 333, Tel. 044 632 29 08, kast@org.chem.ethz.ch).
**Master's Thesis**

Only students who fulfill the following criteria are allowed to begin with their Master's thesis:

- a. successful completion of the Bachelor's programme;
- b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.

Duration of the Master's Thesis: 20 weeks.

**Electives**

Students are free to choose from a range of D-CHAB chemistry courses appropriate to their level of study (please note admission requirements). In case of doubt, contact the student administration.

**Inorganic Chemistry**

- **Abstract**
  - General bonding concepts
  - AIM and ELF as descriptors of electronic structures
  - GCMT model, carbenes and carbene analogues, homo and heteronuclear unsaturated bonds
  - Electron precise cluster, electron deficient cluster, and special cluster

- **Objective**
  - The course starts with an introduction into general concepts allowing to understand why main group element and transition metal compounds from the higher periods show different properties when compared to their lighter congeners. The Atom in Molecule (AIM) Theory and Electron Localization Function (ELF) will be introduced as means to interpret the electron density distribution in molecules. Carbenes and carbene analogues will be discussed as building blocks for compounds with unsaturated bonds which in turn may serve as precursors to inorganic polymers. Electron counting rules allow to distinguish different type of clusters which can be divided into electron precise cluster, various electron deficient cluster (for example Wade-Mingos-Cluster), and special cluster.

  An introduction into general concepts for syntheses and analyses of inorganic polymers will be given. Specifically, polysilanes, polysiloxanes, and polyphosphazenes will be discussed and possible applications of these polymers will be highlighted. Recent literature will be provided and discussed jointly by the participants of the course (flipped classroom).

The man goal of the lecture is to provide a general understanding of the current literature in the field of modern inorganic chemistry with respect to building blocks used for the synthesis of cluster, polymers, and materials.

- **Lecture notes**
  - A handout of the presented material will be distributed to the participants of the course. Articles from recent literature will be provided and discussed in the course.

- **Literature**
  - Original literature is indicated in the course material.

- **Prerequisites / notice**
  - Basis for the understanding of this lecture are the courses Allgemeine Chemie 1&2, and Anorganische Chemie 1: Übergangsmetallichemie.
Understanding and explaining the origin of selectivity in organic synthesis and the application of selective organic reactions to the
Lecture slides will be provided online. A Handout summarizing important concepts in organometallic and physical organic chemistry will
also be provided. Useful references and handouts will also be provided during the workshop.

Slides will be uploaded 1-2 days before each lecture on http://morandi.ethz.ch/education.html

Primary literature and review articles will be cited during the course.

The following textbooks can provide useful support for the course:

Special requirement: each participant will have to come up with an independent research proposal to be presented orally (or handed in in
written form) at the end of the semester. A dedicated workshop will be organized in the middle of the semester to introduce the students to
proposal writing and presentation.

The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is
exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

Concepts of the planning of organic synthesis (strategy and tactics), retrosynthetic analysis. Structure-reactivity relation in the context of
the synthesis of complex molecules.


Required level: Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACIII


The following textbooks can provide useful support for the course:

The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is
exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

Concepts of the planning of organic synthesis (strategy and tactics), retrosynthetic analysis. Structure-reactivity relation in the context of
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Concepts of the planning of organic synthesis (strategy and tactics), retrosynthetic analysis. Structure-reactivity relation in the context of
the synthesis of complex molecules.


Required level: Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACIII

Analytical Competencies

6 credits

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Social Competencies

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

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed

Advanced Magnetic Resonance

6 credits

Does not take place this semester.

Chemical Biology - Peptides

W
6 credits
3G
H. Wennemers

Abstract
An advanced course on the synthesis, properties and function of peptides in chemistry and biology.

Objective
Knowledge of the synthesis, properties and function of peptides in chemistry and biology.

Content
Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.

Literature

Nucleic Acids and Carbohydrates

W
6 credits
3G
K. Lang, P. A. Kast, S. J. Sturla, H. Wennemers

Abstract
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Physical Chemistry

Number
Title
Type
ECTS
Hours
Lecturers

529-0443-01L
Advanced Physical Chemistry: Statistical Thermodynamics
W
6 credits
3G
R. Riek, J. Richardson

Abstract
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Objective
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Content

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

Prerequisites / notice
Chemical Thermodynamics, Reaction Kinetics, Molecular Quantum Mechanics and Spectroscopy; Mathematical Foundations (Analysis, Combinatorial Relations, Integral and Differential Calculus)

Subject-specific Competencies

Concepts and Theories assessed

Analytical Competencies assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Analytical Competencies assessed

Problem-solving assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

529-0433-01L
Advanced Physical Chemistry: Statistical Thermodynamics
W
6 credits
3G
R. Riek, J. Richardson

Abstract
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Objective
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Content

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

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Chemical Thermodynamics, Reaction Kinetics, Molecular Quantum Mechanics and Spectroscopy; Mathematical Foundations (Analysis, Combinatorial Relations, Integral and Differential Calculus)

Subject-specific Competencies

Concepts and Theories assessed

Analytical Competencies assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Analytical Competencies assessed

Problem-solving assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

529-0443-01L
Advanced Magnetic Resonance
W
6 credits
3G
G. Jeschke, A. Barnes

Does not take place this semester.
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. This semester, the lecture will introduce and discuss the dynamics of electron-nuclear spin systems and experiments based on hyperfine interactions in electron paramagnetic resonance (EPR) spectroscopy and dynamic nuclear polarization (DNP) for sensitivity enhancement in NMR.

The course aims at enabling students to understand and design experiments that are based on hyperfine coupling between electron and nuclear spins. This includes analytical and numerical treatment of spin dynamics as well as instrumental aspects. Additionally, students will learn how to use hyperfine couplings to increase sensitivity in solid state NMR via dynamic nuclear polarization (DNP), with an emphasis on the instrumentation required to perform DNP with magic angle spinning (MAS) NMR.

The course is for advanced students and introduces and discusses the theoretical foundations of solid-state nuclear magnetic resonance (NMR).

The aim of the course is to familiarize the students with the basic concepts of modern high-resolution solid-state NMR. Starting from the mathematical description of spin dynamics, important building blocks for multi-dimensional experiments are discussed to allow students a better understanding of modern solid-state NMR experiments. Particular emphasis is given to achieving high spectral resolution.

The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

A script which covers the topics will be distributed in the lecture and will be accessible through the course Moodle.

Analytical Strategy

Abstract
The course is for advanced students and introduces and discusses the theoretical foundations of solid-state nuclear magnetic resonance (NMR).

Objective
The aim of the course is to familiarize the students with the basic concepts of modern high-resolution solid-state NMR. Starting from the mathematical description of spin dynamics, important building blocks for multi-dimensional experiments are discussed to allow students a better understanding of modern solid-state NMR experiments. Particular emphasis is given to achieving high spectral resolution.

Content
The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

Lecture notes
A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.ssnmr.ethz.ch/education/

Prerequisites / notice
Prerequisite: A basic knowledge of NMR, e.g. as covered in the Lecture Physical Chemistry IV, or the book "Spin Dynamics" by Malcolm Levitt.

Analytical Methods for Characterization of Nanoparticles and Nanomaterials

Abstract
Introduction to modern analytical methods used to fully characterize and identify nano-engineered materials and systems.

Objective
Understanding of analytical concepts used in nanotechnology, In-depth knowledge of most important methods used in industry and research, Introduction to selected industrial applications. Basic knowledge of production mechanisms of nano-engineered materials.
Content
Nanotechnology is the basis of many main technological innovations of the 21st century. After more than twenty years of research, nanotechnologies are now increasingly employed for commercial use: they are used in hundreds of everyday consumer products, such as cosmetics, food, automotive, electronics and medical products. Nanoparticles can contribute to stronger, lighter, cleaner, smarter, better, etc. products.

Besides these positive effects, relatively little is still known about potential health and environmental effects and risks of such small nano-sized particles. Therefore, a lot of different industry customers are forced nowadays to monitor and regulate the size and concentration of nanoparticles in their nano-enabled products.

Above and beyond these regulatory requirements, most industries employing nanoparticles need to be able to online measure nanoparticles to meet their requirements towards quality control and production efficiency. All these requirements demand new precise, accurate, fast and innovative analysis methods to fully characterize nanoparticles in real-time and during the manufacturing process.

Lecture notes
Lecture notes will be provided.

Prerequisites / notice
Prerequisites: 529-0051-00 "Analytical Chemistry I (3. Semester)“, 529-0058-00 "Analytical Chemistry II (4. Semester)“ (or equivalent)

Chemical Aspects of Energy

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Steinfeld, E. I. M. Casati</td>
</tr>
</tbody>
</table>

Objective
Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture notes
Lecture Notes containing copies of the presented slides.

Prerequisites / notice

Chemical Crystallography

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0029-01L</td>
<td>Structure Determination</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. D. Wörle, N. Trapp</td>
</tr>
</tbody>
</table>

Abstract
Advanced X-ray crystal structure analysis

Objective
To gain a deeper understanding of crystal structure determination principles and practice by X-ray diffraction and the evaluation of results.

Content
Review of principles of diffraction and instrumentation, unit cells, lattices, and symmetry. Inorganic structural chemistry: sphere packings, ionic crystals, covalent networks, intermetallic compounds. Overview of powder diffraction and application of crystal chemistry for structure analysis of polycrystalline phases. Working safely with X-rays, crystal growth, selection and mounting, data collection strategies, data reduction, corrections for absorption, extinction and Lp, advanced structure solution theory and techniques: Patterson function, heavy atom technique, Fourier methods, direct methods. Structure modeling and refinement, disorder, twinning, false symmetry, interpretation of anisotropic shift parameters. Determination of absolute configuration, interpretation of results and scope of chemically useful information, validation and publication of results, critical evaluation of published crystal structures.

Lecture notes
Information and exercise sheets will be distributed in loose form.
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation.

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that

A set of detailed lecture notes will be provided, which will cover the whole course.

### Literature


### Additional literature


**Prerequisites / notice**

Students will conduct the computational exercises and examples of structure solution and refinement on personal computers.

### Chemical Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4 credits</td>
<td>3V</td>
<td>M. Fussenegger</td>
</tr>
</tbody>
</table>

**Abstract**

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**


**Lecture notes**

Handout during the course.

### Computational Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0003-01L</td>
<td>Advanced Quantum Chemistry</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>M. Reiher, A. Baiardi</td>
</tr>
</tbody>
</table>

**Abstract**

Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer. Examples are:
- Operators derived from principles of relativistic quantum mechanics
- Relativistic effects + methods of relativistic quantum chemistry
- Open-shell molecules + spin-density functional theory
- New electron-correlation theories

**Objective**

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

**Content**

1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group
9) Quantum chemistry without the Born-Oppenheimer approximation

**Lecture notes**

A set of detailed lecture notes will be provided, which will cover the whole course.
Literature
2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997 [english version available: F. Schwabl, Advanced Quantum Mechanics]
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992

Note also the standard textbooks:
A) A. Szabo, N.S. Ostlund. Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Prerequisites / notice
Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

529-0004-01L Classical Simulation of (Bio)Molecular Systems W 6 credits 4G P. H. Hünenberger, J. Dolenc, S. Riniker

Objective
Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature
See: www.csms.ethz.ch/education/CSBMS

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

Material Science

Number Title Type ECTS Hours Lecturers
327-0703-00L Electron Microscopy in Material Science W 4 credits 2V+2U S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze

Abstract
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content
This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Lecture notes
will be distributed in English

Literature
Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

402-0468-15L Nanomaterials for Photonics W 6 credits 2V+1U R. Grange

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based,...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures,...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.
Content

1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes
Course material will be handed out as the lectures progress

Literature
Textbooks of pharmacology and toxicology (cf. list in course material)

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

Environmental Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0745-01L</td>
<td>General and Environmental Toxicology</td>
<td>W</td>
<td>6</td>
<td>3V</td>
<td>M. Arand, H. Nägeli</td>
</tr>
</tbody>
</table>

Abstract
Toxicokinetic and toxicodynamic aspects of xenobiotic interactions with cellular structures and mechanisms. Toxic responses at the level of organs (immune-, neuro-, reproductive and genotoxicity) and organisms. Introduction into developmental toxicology and ecotoxicology.

Objective
Understanding of the impact of chemicals on biological systems; evaluation of the effects from different biomedical perspectives.

Content
Explanation of important interactions between xenobiotic chemicals and cellular structures such as membranes, enzymes, and nucleic acids. Relevance of intake, distribution, excretion, and biochemical transformation processes. Relevance of mixtures. Explanation of important modes of toxic action such as immuno toxicity, neurotoxicity, reproduction toxicity, genotoxicity based on examples of certain xenobiotics and their effects on important organs.

Economics and Technology Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>363-0389-00L</td>
<td>Technology and Innovation Management</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Brusoni, A. Zeijen</td>
</tr>
</tbody>
</table>

Course material will be handed out as the lectures progress

Textbooks of pharmacology and toxicology (cf. list in course material)

Educational basis: basic chemistry, biology and biochemistry
Abstract

This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

Objective

This course intends to enable all students to:

- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

Content

This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small. How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, guest speakers, simulations and group work.

Lecture notes

Slides will be available on the Moodle page

Literature

Readings will be available on the Moodle page

Prerequisites / notice

The course content and methods are designed for students with some background in management and/or economics

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

363-0565-00L  

Principles of Macroeconomics

W  3 credits  2V  J.-E. Sturm

Abstract

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

Objective

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

Content

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

Lecture notes

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

Literature

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

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>not assessed</td>
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</tr>
<tr>
<td>Personal Competencies</td>
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</tr>
</tbody>
</table>

363-0503-00L  

Principles of Microeconomics

W  3 credits  2G  M. Filippini

Abstract

This book (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.
Objective

The learning objectives of the course are:

- Students must be able to discuss basic principles, problems and approaches in microeconomics.
- Students can analyse and explain simple economic principles in a market using supply and demand graphs.
- Students can contrast different market structures and describe firm and consumer behaviour.
- Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
- Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
- Students can apply simple mathematical concepts on economic problems.

Content

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes

Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature


For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:


For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

The book can also be used for the course 'Principles of Macroecomics' (Sturm)

Prerequisites / notice

Complementary:

Taught

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Lecturers

H. Grützmacher, J. Grützmacher

Mikroökonomie.

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Social Competencies

Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies

Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Inorganic Chemistry

Aspects of Modern Inorganic Chemistry: Concepts, Building Blocks, and Polymers

W+ 6 credits 3G

H. Grützmacher, J. Grützmacher

General bonding concepts
AIM and ELF as descriptors of electronic structures
GCMT model, carbenes and carbene analogues, homo and heteronuclear unsaturated bonds
Electron precise cluster, electron deficient cluster, and special cluster
General concepts and definitions of inorganic polymers, polysilanes, polysiloxanes, polyphosphazenes

The course starts with an introduction into general concepts allowing to understand why main group element and transition metal compounds from the higher periods show different properties when compared to their lighter congeners. The Atom in Molecule (AIM) Theory and Electron Localization Function (ELF) will be introduced as means to interpret the electron density distribution in molecules. Carbenes and carbene analogues will be discussed as building blocks for compounds with unsaturated bonds which in turn may serve as precursors to inorganic polymers. Electron counting rules allow to distinguish different type of clusters which can be divided into electron precise cluster, various electron deficient cluster (for example Wade-Mingos-Cluster), and special cluster.

An introduction into general concepts for syntheses and analyses of inorganic polymers will be given. Specifically, polysilanes, polysiloxanes, and polyphosphazenes will be discussed and possible applications of these polymers will be highlighted.

Recent literature will be provided and discussed jointly by the participants of the course (flipped classroom).

The man goal of the lecture is to provide a general understanding of the current literature in the field of modern inorganic chemistry with respect to building blocks used for the synthesis of cluster, polymers, and materials.
The course aims at enabling students to understand and design experiments that are based on hyperfine coupling between electron and nuclear spins. Building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

Based on these foundations, we discuss polarization transfer from the electron to the nuclear spin and back, as well as spin diffusion as a mechanism for polarizing nuclear spins beyond the immediate vicinity of the electron spin. The second half of the course will cover dynamic nuclear polarization (DNP), with a focus on instrumentation required to perform DNP with magic angle spinning (MAS) NMR.

Does not take place this semester.
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

The underlying lecture (529-0051-00L) is offered in autumn semester but only in German.

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications.

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

Lecture notes
Script will be provided for the production price

Literature
- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995
- E. Pretsch, P. Bußmann, C. Affolter, M. Badertscher, Spektroskopische Daten zur Strukturaufklärung organischer verbindungen, 4. Auflage, Springer, Berlin/Heidelberg, 2001-

Prerequisites / notice
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

529-0058-AAL
Analytical Chemistry II

Abstract
Enhanced knowledge about the elemental analysis and spectroscopical techniques with close relation to practical applications. This course is based on the knowledge from analytical chemistry I. Separation methods are included.

Objective
Use and applications of the elemental analysis and spectroscopical knowledge to solve relevant analytical problems.

Content
Combined application of spectroscopic methods for structure determination, and practical application of element analysis. More complex NMR methods: recording techniques, application of exchange phenomena, double resonance, spin-lattice relaxation, nuclear Overhauser effect, applications of experimental 2d and multipulse NMR spectroscopy, shift reagents. Application of chromatographic and electrophoretic separation methods: basics, working technique, quality assessment of a separation method, van-Deemter equation, gas chromatography, liquid chromatography (HPLC, ion chromatography, gel permeation, packing materials, gradient elution, retention index), electrochemistry, electrosmotic flow, zone electrophoresis, capillary electrophoresis, isoelectrical focussing, electrochromatography, 2d gel electrophoresis, ESI-MS, field flow fractionation, enhanced knowledge in atomic absorption spectroscopy, atomic emission spectroscopy, X-ray fluorescence spectroscopy, ICP-OES, ICP-MS.

Literature

Prerequisites / notice
None.

529-0132-AAL
Inorganic Chemistry III: Organometallic Chemistry and Homogeneous Catalysis

Abstract
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbynonation, C-C bond-forming and related reactions.

Objective
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

Content
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbynonation, C-C bond-forming and related reactions.

This course does not offer a lecture of its own but it is linked to the course 529-0132-00L.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 495 of 2345
This is an introductory course in quantum mechanics. The course starts with an overview of the fundamental concepts of quantum mechanics and introduces the mathematical formalism. The postulates and theorems of quantum mechanics are discussed in the context of experimental and numerical determination of physical quantities. The course develops the tools necessary for the understanding and calculation of elementary quantum phenomena in atoms and molecules.

**Literature**


**Teaching competencies**

**Subject-specific Competencies**

- Concepts and Theories

- Problem-solving

- Creative Thinking

- Critical Thinking

**Taught by**

G. Jeschke (11 credits)

F. Merkt (4 credits)

V. Mougel (11 credits)

529-0431-AAL **Physical Chemistry III: Molecular Quantum Mechanics**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Postulates of quantum mechanics, operator algebra, Schrödinger's equation, state functions and expectation values, matrix representation of operators, particle in a box, tunneling, harmonic oscillator, molecular vibrations, angular momentum and spin, generalised Pauli principle, perturbation theory, electronic structure of atoms and molecules, Born-Oppenheimer approximation.

**Objective**

This is an introductory course in quantum mechanics. The course starts with an overview of the fundamental concepts of quantum mechanics and introduces the mathematical formalism. The postulates and theorems of quantum mechanics are discussed in the context of experimental and numerical determination of physical quantities. The course develops the tools necessary for the understanding and calculation of elementary quantum phenomena in atoms and molecules.

**Content**


**Literature**


529-0432-AAL **Physical Chemistry IV: Magnetic Resonance**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Theoretical foundations of magnetic resonance (NMR,EPR) and selected applications.

**Objective**

Introduction to magnetic resonance in isotropic and anisotropic phase.

**Content**

The course gives an introduction to magnetic resonance spectroscopy (NMR and EPR) in liquid, liquid crystalline and solid phase. It starts from a classical description in the framework of the Bloch equations. The implications of chemical exchange are studied and two-dimensional exchange spectroscopy is introduced. An introduction to Fourier spectroscopy in one and two dimensions is given and simple 'pulse trickery' is described. A quantum-mechanical description of magnetic resonance experiments is introduced and the spin Hamiltonian is derived. The chemical shift term as well as the scalar, dipolar and quadrupolar terms are discussed. The product-operator formalism is introduced and various experiments are described, e.g. polarization transfer. Applications in chemistry, biology, physics and medicine, e.g. determination of 3D molecular structure of dissolved molecules, determination of the structure of paramagnetic compounds and imaging (MRI) are presented.

**Lecture notes**

handed out in the lecture (in english)

**Literature**

see [http://www.ssnmr.ethz.ch/education/PC_IV_Lecture](http://www.ssnmr.ethz.ch/education/PC_IV_Lecture)

529-0129-AAL **Inorganic and Organic Chemistry II**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction to the experimental methods of Inorganic Chemistry

**Objective**

The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc.. The synthesis, characterization and analysis of inorganic compound are a main topic. Emphasis is given to scientific writing (experiment reports).

**Content**

Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Synthesis of organo-boron compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Ph catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

**Lecture notes**

A manual is distributed in the teaching laboratory.
Prerequisites / notice

Prerequisites:
- Practical Course General Chemistry (1. Semester, 529-0011-04)
- Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)
- Attendance of Course Inorg. Chemistry 1 (3. Sem., 529-0121)

If necessary, access priority will be settled according to the results of the first-year examinations.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

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**Chemistry Master - Key for Type**

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

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**Key for Hours**

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

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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

Objective
We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

Content
Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Pécel number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small Volume Molecular Detection
Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Lecture notes
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

Literature
There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

529-0615-01L Biochemical and Polymer Reaction Engineering W+ 6 credits 3G P. Arosio

Abstract

Objective
The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stage of the design approach, where conditions of diffusion and reaction limited aggregation, Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

**Lecture notes**
Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html
Additional handout of slides will be provided during the lectures.

**Literature**
H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

### Products and Materials

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0619-01L</td>
<td><strong>Chemical Product Design</strong></td>
<td>W+</td>
<td>6</td>
<td>3G</td>
<td>W. J. Stark</td>
</tr>
</tbody>
</table>

**Prerequisites:** Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

**Abstract**
The 'Chemical Product Design' course teaches students quantitative concepts to analyze, select and transform theoretical concepts from chemistry and engineering into valuable real-world products. Basic chemistry and chemical engineering knowledge is required (Diffusion, Thermodynamics, Kinetics,...).

**Objective**
This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g. responsive building materials, personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or compound, and the necessary steps to pursue the resulting project within an entrepreneurial environment. We therefore extend the questions of process design ('how do we make something?') to the question of 'what should we make?'

**Content**

#### Part A: 'The Chemical Product Design' course starts with discussing questions along: What is a chemical product, and why do people pay for it? How does a given compound in a specific setting provide a service? We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

Students are expected to actively develop chemical products along the course. Contributions will be made individually, or in small groups, where a larger topic is studied.

**Literature**


**Prerequisites / notice**
Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

### Process Design

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0643-01L</td>
<td><strong>Process Design and Development</strong></td>
<td>W+</td>
<td>6</td>
<td>3G</td>
<td>G. Guillén Gosálbez</td>
</tr>
</tbody>
</table>

**Abstract**
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

**Objective**
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stage of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

**Content**
Process creation: heuristics vs. mathematical programming.
Heuristics for reaction and separation operations, heat transfer and pressure change.
Introduction to optimization in process engineering and the modeling software GAMS.
Process economic evaluation: equipment sizing and costing, time value of money, cash flow calculations.
Process integration: sequencing of distillation columns using mixed-integer linear programming (MILP), and synthesis of heat exchanger networks using mixed-integer nonlinear programming (MINLP).
Batch processes: scheduling, sizing, and inventories.
Principles of molecular design using mixed-integer programming.

**Lecture notes**
no script
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:

- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Prerequisite: Basic knowledge on unit operations, mainly reaction engineering and distillation. It is recommended that the student takes the module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

### Literature

**Main books**


**Other references**


**Prerequisites / notice**

- An exemplary literature list is provided below:
  - Smith, R. Chemical process design and integration, Wiley (2005).

###催化与分离

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
151-0927-00L | Rate-Controlled Separations in Fine Chemistry | W+ | 6 credits | 3V+1U | M. Mazzotti, V. Becattini

**Abstract**

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.

**Objective**

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.
Case Studies in Process Design

The aspects described above will be demonstrated through industrially-relevant examples such as:

- To accelerate the discovery and implementation of sustainable technologies, this vibrant discipline is constantly refining its design principles, particularly at the nanoscale, a shift facilitated by the availability of increasingly powerful tools that permit the continued development of fundamental knowledge over different time and length scales. During this course, you will learn current concepts for the defossilization of the chemical industry and strategies for achieving this goal from idea to implementation. By introducing topical case studies both in lectures and through a semester project, you will see aspects of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalysis design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

- A supervised semester project conducted in small groups provides a taster of catalysis research on a timely topic. Students will learn basic skills including critical literature analysis, problem definition and solving, methods of catalyst synthesis, characterization, and testing, and data evaluation and communication through a short talk.

- The course material is based on slides and journal articles.

- It is assumed that students selecting this course are familiar with basic concepts of chemistry and catalysis (chemistry or chemical engineering background). Other students are welcome to contact us to discuss the requirement for prior knowledge.

## Case Study

### 529-0459-01L Case Studies in Process Design

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

**Abstract**

The learning objective is to design, simulate and optimize a real (bio-)chemical process from a process systems perspective. Specifically, a commercial process simulation software (Aspen) will be used for the process simulation and optimization. Students have to integrate knowledge and develop engineering thinking and skills acquired in the other courses of the curriculum.

**Objective**

Simulate and optimize a chemical process using commercial process simulation software.

**Content**

- Students will apply a commercial process simulator systematically for process creation and analysis.
- Students will create a process simulation flowsheet for steady-state simulation.

Evaluate the performance of the production process

- Students will analyse and understand the degrees of freedom in modelling process units and flowsheets.
- Students will understand the role of process simulators in process creation.
- Students will make design specifications and follow the iterations implemented to satisfy them.
- Students will judge the role of process simulators in equipment sizing and costing and profitability analysis.
- Students will assess the economic performance of the process, including operating costs (OPEX), and capital investment (CAPEX), based on the outcome of the simulation model.
- Students will assess the environmental impact of the production process following the Life Cycle Assessment (LCA) methodology.

Optimize the design and operating conditions of the production process

- Students will carry out sensitivity analyses and optimizations considering technical and economic criteria.
- Students will generate process integration alternatives to improve the initial design.
- Students will optimize the production process considering economic and environmental criteria.
Before the case study week, students are encouraged to participate in the exercises of the course "Process Simulation and Flowsheeting" in order to get familiar with the Aspen Plus simulation software (this is highly recommended, but not mandatory). The problem statement and detailed instructions are provided in the project brief made available at the beginning of the case study week.

During the case study week:
- Students work in teams of 4-6 people.
- Students have to pose and solve process equipment and system design related problems.
- Students have to coordinate the activities, the preparation of the written report and the oral presentation.
- Students get support from project assistants and the course supervisor.

The groups deliver the written report on a predefined date.

The students receive the feedback and are asked to implement some changes in their reports.

A final presentation takes place summarizing the main findings of the project.

### Research Project or Industry Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0300-10L</td>
<td>Research Project</td>
<td>W</td>
<td>13</td>
<td>16A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.</td>
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<tr>
<td>Objective</td>
<td>First contact with experimental techniques of chemical engineering in a research group. Critical evaluation and presentation of the results in a scientific report.</td>
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<tr>
<td>Content</td>
<td>This laboratory project is organised during the spring vacation before the sixth semester. The participant can choose his topic from the list of projects suggested. Main emphasis during this research work is to get experience in using different engineering tools and evaluation and the interpretation of the results. Those are presented as a scientific report.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0301-00L</td>
<td>Industry Internship</td>
<td>W</td>
<td>13</td>
<td>Supervisors</td>
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<tr>
<td>Abstract</td>
<td>Internship in industry with a minimum duration of 7 weeks</td>
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<tr>
<td>Objective</td>
<td>The aim of the internship is to make students acquainted with industrial work environments. During this time, they will have the opportunity to get involved in current projects of the host institution.</td>
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<tr>
<td>Content</td>
<td>This laboratory project is organised during the spring vacation before the sixth semester. The participant can choose his topic from the list of projects suggested. Main emphasis during this research work is to get experience in using different engineering tools and evaluation and the interpretation of the results. Those are presented as a scientific report.</td>
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### Master's Thesis

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0600-10L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>25</td>
<td>54D</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Objective</td>
<td>Only students who fulfill the following criteria are allowed to begin with their Master's thesis: a. successful completion of the Bachelor's programme; b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.</td>
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</tr>
<tr>
<td>Content</td>
<td>Duration of the Master's Thesis 20 weeks.</td>
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</table>

### Electives

#### Biochemical Engineering

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>M. Fussenegger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Lecture notes</td>
<td>Handout during the course.</td>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td>Abstract</td>
<td>Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).</td>
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<tr>
<td>Objective</td>
<td>The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.</td>
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</tbody>
</table>
Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing large-scale network organization. These include (i) graph theoretical approaches with probabilistic (Bayesian) network representations, (ii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes
http://www.csb.ETHZ.ch/education/lectures.html


<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1714-00L</td>
<td>Biomaterials</td>
<td>W 4</td>
<td>3V</td>
<td>K. Maniura, M. Rottmar, M. Zenobi-Wong</td>
</tr>
<tr>
<td>529-0615-01L</td>
<td>Biochemical and Polymer Reaction Engineering</td>
<td>W 6</td>
<td>3G</td>
<td>P. Arosio</td>
</tr>
<tr>
<td>529-0837-01L</td>
<td>Biomicrofluidic Engineering</td>
<td>W 6</td>
<td>3G</td>
<td>A. de Mello</td>
</tr>
</tbody>
</table>

**Abstract**

- **Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues).** The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

- **Objective**
  1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
  2. The concept of biocompatibility.
  3. Introduction into methodology used in biomaterials research and application.
  4. Introduction to different material classes in use for medical applications.

- **Content**
  - Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Differe focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.
  - Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.
  - A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

- **Lecture notes**
  - Handouts are deposited online (moodle).

- **Literature**
  - (available online via ETH library)

- **Handouts and references therin.**

- **Abstract**

- **Objective**
  - The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

- **Content**
  - We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes. Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

- **Lecture notes**
  - Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html
  - Additional handout of slides will be provided during the lectures.

- **Literature**
Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small volume Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
    Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Lecture Notes
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

Literature
There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Taught Competencies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Steinfeld, E. I. M. Casati</td>
</tr>
<tr>
<td>Objective</td>
<td>Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.</td>
<td></td>
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</tr>
<tr>
<td>Lecture Notes</td>
<td>Lecture Notes containing copies of the presented slides.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites</td>
<td>Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.</td>
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</tbody>
</table>

529-0659-00L   | Electrochemistry: Fundamentals, Cells & Applications | W    | 6    | 3G    | L. Gubler                  |
| Objective      | Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion. |

Environment and Energy
Content
- Introduction: important quantities & units, terminology;
- Chapter I - Redox reactions, Faraday's laws;
- Chapter II - Equilibrium electrochemistry: cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces: electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes: conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry: overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry: electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion: important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors: potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion: corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

Lecture notes

Prerequisites / notice
Students should be familiar with the fundamentals of physical chemistry.

Taught competencies
- General and Environmental Toxicology: toxicokinetic and toxicodynamic aspects of xenobiotic interactions with cellular structures and mechanisms. Toxic responses at the level of organs (immune-, neuro-, reproductive and genotoxicity) and organisms. Introduction into developmental toxicology and ecotoxicology.
- Systems and Process Engineering: basic chemistry, biology and biochemistry
- Molecular Aspects of Catalysts and Surfaces: basic elements of surface science important for materials and catalysis research. Physical and chemical methods important for research in surface science, material science and catalysis are considered and their application is demonstrated on practical examples.
- Modeling and Simulations: methods which are covered embrace: Gas adsorption and surface area analysis, IR-Spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, X-ray absorption, solid state NMR, Electron Microscopy and others.

Systems and Process Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0745-01L</td>
<td>General and Environmental Toxicology</td>
<td>W</td>
<td>6</td>
<td>3V</td>
<td>M. Arand, H. Nägeli</td>
</tr>
<tr>
<td>Abstract</td>
<td>Toxicokinetic and toxicodynamic aspects of xenobiotic interactions with cellular structures and mechanisms. Toxic responses at the level of organs (immune-, neuro-, reproductive and genotoxicity) and organisms. Introduction into developmental toxicology and ecotoxicology.</td>
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<tr>
<td>Objective</td>
<td>Understanding of the impact of chemicals on biological systems; evaluation of the effects from different biomedical perspectives.</td>
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<tr>
<td>Content</td>
<td>Explanation of important interactions between xenobiotic chemicals and cellular structures such as membranes, enzymes, and nucleic acids. Relevance of intake, distribution, excretion, and biochemical transformation processes. Relevance of mixtures. Explanation of important modes of toxic action such as immuno toxicity, neurotoxicity, reproduction toxicity, genotoxicity based on examples of certain xenobiotics and their effects on important organs.</td>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0611-01L</td>
<td>Molecular Aspects of Catalysts and Surfaces</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>J. A. van Bokhoven, D. Ferri</td>
</tr>
<tr>
<td>Abstract</td>
<td>Basic elements of surface science important for materials and catalysis research. Physical and chemical methods important for research in surface science, material science and catalysis.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Basic aspects of surface science. Understanding of principles of most important experimental methods used in research concerned with surface science, material science and catalysis.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Methods which are covered embrace: Gas adsorption and surface area analysis, IR-Spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, X-ray absorption, solid state NMR, Electron Microscopy and others.</td>
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Modeling and Simulations

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 505 of 2345
The set-up of the course will closely follow the book of Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

### Economics and Technology Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0389-00L</td>
<td>Technology and Innovation Management</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Brusoni, A. Zeijen</td>
</tr>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>J.-E. Sturm</td>
</tr>
</tbody>
</table>

**Abstract**

This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

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

**Objective**

This course intends to enable all students to:
- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

**Content**

This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, guest speakers, simulations and group work.

**Lecture notes**

Slides will be available on the Moodle page

**Prerequisites / notice**

The course content and methods are designed for students with some background in management and/or economics

**Taught competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Personal Competencies: Critical Thinking

**Literature**

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

This book can also be used for the course '363-0503-00L Principles of Macroeconomics' (Filippini). Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
Principles of Microeconomics

Abstract
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

Objective
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can apply simple mathematical concepts on economic problems.
6. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
7. Students can apply simple mathematical concepts on economic problems.

Content
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
The book can also be used for the course Principles of Macroeconomics (Sturm)
For students taking only the course Principles of Microeconomics there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where a larger topic is studied. Students are expected to actively develop chemical products along the course. Contributions will be made individually, or in small groups, where a larger topic is studied.

**Literature**


**Prerequisites / notice**

Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...)

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### Products and Materials

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0619-01L</td>
<td><strong>Chemical Product Design</strong></td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>W. J. Stark</td>
</tr>
</tbody>
</table>

**Abstract**
The 'Chemical Product Design' course teaches students quantitative competencies to analyze, select and transform theoretical concepts from chemistry and engineering into valuable real-world products. Basic chemistry and chemical engineering knowledge is required (Diffusion, Thermodynamics, Kinetics,...).

**Objective**
This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g. responsive building materials; personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or compound, and the necessary steps to batch processes: scheduling, sizing, and inventories, networks using mixed-integer nonlinear programming (MINLP).

**Content**

Part A: The 'Chemical Product Design' course starts with discussing questions along, 'What is a chemical product, and why do people pay for it? How does a given compound in a specific setting provide a service? We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

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### Process Design

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0643-01L</td>
<td><strong>Process Design and Development</strong></td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>G. Guillén Gosálbez</td>
</tr>
</tbody>
</table>

**Abstract**
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

**Objective**
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

**Content**

Process creation: heuristics vs. mathematical programming.
Heuristics for reaction and separation operations, heat transfer and pressure change. Introduction to optimization in process engineering and the modeling software GAMS.
Process integration: sequencing of distillation columns using mixed-integer linear programming (MILP), and synthesis of heat exchanger networks using mixed-integer nonlinear programming (MINLP).
Batch processes: scheduling, sizing, and inventories, Principles of molecular design using mixed-integer programming.

**Lecture notes**
no script
Literature

Main books

Other references

Prerequisites / notice

529-0613-01L Process Simulation and Flowsheeting  W  6 credits  3G  G. Guillén Gosálbez

Objective

This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization.
Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Content

Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
  - Non-linear programming, NLP
  - Mixed-integer linear programming, MILP
  - Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

Literature

An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice

A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

>>> Catalysis and Separation

Number Title Type ECTS Hours Lecturers
151-0927-00L Rate-Controlled Separations in Fine Chemistry W  6 credits  3V+1U  M. Mazzotti, V. Becattini

Abstract

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life sciences processes in particular, fine chemistry and biotechnology, and in energy-related applications.

Objective

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life sciences processes in particular, fine chemistry and biotechnology.
The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

### Content

The course material is based on slides and journal articles. It is assumed that students selecting this course are familiar with basic concepts of chemistry and catalysis (chemistry or chemical engineering background). Other students are welcome to contact us to discuss the requirement for prior knowledge.

### Lecture notes

Handouts during the class

### Literature

Recommendations for text books will be covered in the class

### Prerequisites

Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

### Taught competencies

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

Method-specific Competencies
- Analytical Competencies
  - assessed
- Decision-making
  - not assessed
- Media and Digital Technologies
  - not assessed
- Problem-solving
  - assessed
- Project Management
  - not assessed

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

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

### Objective

To accelerate the discovery and implementation of sustainable technologies, this vibrant discipline is constantly refining its design principles, particularly at the nanoscale, a shift facilitated by the availability of increasingly powerful tools that permit the continued development of fundamental knowledge over different time and length scales. During this course, you will learn current concepts for the defossilization of the chemical industry and strategies for achieving this goal from idea to implementation. By introducing topical case studies both in lectures and through a semester project, you will see aspects of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalyst design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

### Content

A supervised semester project conducted in small groups provides a taster of catalysis research on a timely topic. Students will learn basic skills including critical literature analysis, problem definition and solving, methods of catalyst synthesis, characterization, and testing, and data evaluation and communication through a short talk.

### Science in Perspective

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-CHAB
  - see Science in Perspective: Language Courses ETH/UZH

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0051-AAL</td>
<td>Analytical Chemistry I (529-0051-AAL)</td>
<td>3</td>
<td>6R</td>
<td>D. Günther, R. Zenobi</td>
</tr>
</tbody>
</table>

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

The underlying lecture (529-0051-00L) is offered in autumn semester but only in German.

### Abstract

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

### Objective

Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications.
Content

Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

Lecture notes

Script will be provided for the production price

Literature

- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

Prerequisites / notice

Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

<table>
<thead>
<tr>
<th>Chemical and Bioengineering Master - Key for Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
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<tr>
<td>W+</td>
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<table>
<thead>
<tr>
<th>Key for Hours</th>
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<tbody>
<tr>
<td>V lecture</td>
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<tr>
<td>G lecture with exercise</td>
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<tr>
<td>U exercise</td>
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<tr>
<td>S seminar</td>
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<tr>
<td>K colloquium</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Chemical Engineering Bachelor

1. Semester

Compulsory Subjects First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-02L</td>
<td>General Chemistry (inorganic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewiss acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.</td>
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</tr>
</tbody>
</table>

| 529-0011-03L| General Chemistry (Organic Chemistry) I   | O    | 3    | 2V+1U   | P. Chen     |
| Abstract    | Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions. |
| Objective   | Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicity, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intermolecular interactions. |
| Lecture notes | Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt |

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

| 529-0011-01L| General Chemistry (Physical Chemistry) I  | O    | 3    | 2V+1U   | H. J. Wörner  |
| Abstract    | The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding. |
| Objective   | After the lecture, students will be able to, |
|             | - to calculate physical quantities and their units which are important for chemistry, |
|             | - name some properties of chemically relevant particles and propose experimental methods to determine these properties, |
|             | - name applications and hazards of radioactivity, |
|             | - categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them, |
|             | - describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection, |
|             | - to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them, |
|             | - analyze and calculate absorption and emission spectra of single-electron atoms, |
|             | - to set up the Schrödinger equation for a molecular multi-particle system, |
|             | - independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems, |
|             | - model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model, |
|             | - explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom, |
|             | - explain the structure of the periodic table of elements with the help of the orbital concept, |
|             | - recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and |
|             | - establish term symbols for atomic ground states. |
| Content     | Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions, Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals. |
| Lecture notes | See homepage of the lecture. |
| Literature  | See homepage of the lecture. |
| Prerequisites / notice | Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung. |
### Concepts and Theories

**402-0043-00L**

**Physics I**

- Type: assessed
- Hours: 3V+1U
- ECTS: 4
- Literature: S. P. Quanz

**Abstract**

Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.

**Objective**

The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

**Content**

Mechanics (motion, Newton’s laws, work and energy, conservation of momentum, rotation, gravitation, fluids), periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

**Lecture notes**

The lecture follows the book “Physics” by Paul A. Tipler.

**Literature**

- H. V. Schönberg
- Adaptability and Flexibility
- Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company
- Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.

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**401-0271-00L**

**Mathematical Foundations I: Analysis A**

- Type: assessed
- Hours: 3V+2U
- ECTS: 5
- Literature: M. Felder

**Abstract**

Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

**Objective**

Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

**Content**

Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

**Lecture notes**

The lecture follows the book “Mathematics for Engineers and Computer Scientists” by M. Felder.

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**529-0001-00L**

**Introduction to Computer Science**

- Type: assessed
- Hours: 2V+2U
- ECTS: 4
- Literature: P. H. Hünenberger

**Abstract**

Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

**Objective**

Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation; Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

**Lecture notes**

Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.

**Prerequisites / notice**

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/infol

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**Laboratory Courses**

- **Number**: 529-0011-04L
- **Title**: Practical Course General Chemistry
- **Type**: O
- **ECTS**: 8
- **Hours**: 12P
- **Lecturers**: H. V. Schönberg, E. C. Meister
- **Latest online enrolment is 19.09.2022**

**Abstract**

Qualitative analysis (determination of cations and anions), acid-base-equilibria (pH-values, titrations, buffer), precipitation equilibria (gravimetry, potentiometry, conductivity), redox reactions (syntheses, redox-titrations, galvanic elements), metal complexes (syntheses, complexometric titration).

Analysis of measured data, vapour pressure, conductivity, calorimetry, solubility.
Objective
Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffers systems, Kjeldahl determination), precipitation equilibria (graviometry, potentiometry, conductivity), oxidation state and redox behaviour (syntheses, redox-titration, galvanic elements), metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration) analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimetry, solubility).

Content
The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their state of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes
http://www.gruetzmacher.ethz.ch/education/lobcourses

Literature
Moodle Lernplattform

Prerequisites / notice
Compulsory: online enrolment latest one week after start of the semester

Safety concept:
https://chab.ethz.ch/studium/bachelor1.html

# 3. Semester

### Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0121-00L</td>
<td>Inorganic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. Grützmacher, P. Steinegger</td>
</tr>
</tbody>
</table>

**Abstract**
Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals as well as the lanthanides and actinides. Introduction of methods of characterization, physical-chemical properties of coordination compounds as well as principles of radiochemistry.

**Objective**
The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. The students will acquire knowledge on the fundamentals of radioactive decay and radiochemistry. Furthermore, they will be familiar with the basics of inorganic chemistry of lanthanides and actinides.

**Content**
This course consists of the following parts, which introduce the students to the chemistry of transition metals as well as lanthanides and actinides: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) Properties and characterization of coordination compounds; 9) Introduction to radiochemistry; 10) Principles of the chemistry of the lanthanides and actinides.

**Lecture notes**
Eine kommentierte Foliensammlung ist im HCI-Shop erhältlich.

**Literature**

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

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0221-00L</td>
<td>Organic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. Wennemers</td>
</tr>
</tbody>
</table>

**Abstract**
This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

**Objective**
The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.

**Content**

**Lecture notes**
The lecture slides, problem sets, and additional documents are provided online. Link: https://wennemers.ethz.ch/education.html

**Literature**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>R. Signorell</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to Chemical Reaction Kinetics

Content
- Fundamentals: rate laws, elementary reactions and composite reactions, molecularity, reaction order. Experimental methods in reaction kinetics up to new developments in femtosecond kinetics.
- Simple chemical reaction rate theories: temperature dependence of the rate constant and Arrhenius equation, collision theory, reaction cross-section, transition state theory. Reaction mechanisms and complex kinetic systems, approximation techniques, chain reactions, explosions and detonations. Homogeneous catalysis and enzyme kinetics.

Literature

Prerequisites / notice
- Voraussetzungen:
  - Mathematik I und II
  - Allgemeine Chemie I und II
  - Physikalische Chemie I

Analysis of Organic Compounds

Abstract
- Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
- Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content
- Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
  -Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
  -NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
  -IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.
  -UV/VIS spectroscopy: Basics, interpretation of electron spectra. Circular dichroism (CD) and optical rotation dispersion (ORD).

Prerequisites / notice
- Excercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

Laplace's Equation

Abstract

Objective
- Classical tools to solve the most common linear partial differential equations.

Content
1) Examples of partial differential equations
- Classification of PDEs
- Superposition principle
2) One-dimensional wave equation
- D'Alembert's formula
- Duhamel's principle
3) Fourier series
- Representation of piecewise continuous functions via Fourier series
- Examples and applications
4) Separation of variables
- Solution of wave and heat equation
- Homogeneous and inhomogeneous boundary conditions
- Dirichlet and Neumann boundary conditions
5) Laplace equation
- Solution of Laplace's equation on the rectangle, disk and annulus
- Poisson formula
- Mean value theorem and maximum principle
6) Fourier transform
- Derivation and definition
- Inverse Fourier transformation and inversion formula
- Interpretation and properties of the Fourier transform
- Solution of the heat equation
7) Laplace transform (if time allows)
- Definition, motivation and properties
- Inverse Laplace transform of rational functions
- Application to ordinary differential equations

Lecture notes
See the course web site (linked under Lernmaterialien)
Literature


Additional books:


4) E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1,2,11,12,6)

Prerequisites / notice

For additional sources, see the course web site (linked under Lernmaterialien)

Prerequisites / notice

Required background:

1) Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant

2) Multiple integrals: Riemann integrals in two or three variables, change of variables

3) Sequences and series of numbers and of functions

4) Basic knowledge of ordinary differential equations

Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0129-00L</td>
<td>Inorganic and Organic Chemistry II</td>
<td>O</td>
<td>11 credits</td>
<td>16P</td>
<td>V. Mougel</td>
</tr>
</tbody>
</table>

Latest online enrolment is one week before the beginning of the semester.

Abstract

The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a main topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques.

Content

Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Lecture notes

A manual is distributed in the teaching laboratory.

Prerequisites / notice

- Passed Basisprüfung
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)
- Continuous Attendance of Course Inorg. Chemistry I (3. Sem., 529-0121) and Analytical Chemistry 1 (3. Sem., 529-0051)

If necessary, access priority will be settled according to the results of the first-year examinations.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Decision-making assessed

Media and Digital Technologies assessed

Problem-solving assessed

Project Management assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation not assessed

Leadership and Responsibility assessed

Self-presentation and Social Influence not assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Adaptability and Flexibility assessed

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-awareness and Self-reflection assessed

Self-direction and Self-management assessed

5. Semester

Compulsory Subjects

Chemical Engineering Thermodynamics

This course introduces the basic principles and concepts of chemical engineering thermodynamics. Whilst providing insights into the meaning and properties of fundamental thermodynamic quantities, the course also has a primary focus on the application of thermodynamic concepts to real chemical engineering problems.
A primary objective of the course is to present a rigorous treatment of classical thermodynamics, whilst retaining a strong engineering perspective. Accordingly, real-world engineering examples will be used to highlight how thermodynamics is applied in engineering practice. The core ideas presented and developed within the course will provide a foundation for subsequent studies in such fields as fluid mechanics, heat transfer and statistical thermodynamics.

The first part of the course introduces the basic concepts and language of chemical engineering thermodynamics. This is followed by an analysis of energy and energy transfer, with a specific focus on the concept of work and the first law of thermodynamics. Next, the notion of a pure substance is introduced, with a discussion of the physics of phase-changes being presented. The description of pure substances is further developed through an analysis of the PVT behavior of fluids, equation of states, ideal and non-ideal gas behaviour and compressibility factors.

The second part of the course begins with a discussion of the use of the energy balance relation in closed systems that involve pure substances and then develops relations for the internal energy and enthalpy of ideal gases. Next, the second law of thermodynamics is introduced, with a discussion of why processes occur in certain directions and why energy has quality as well as quantity. Applications to cyclic devices such as thermal energy reservoirs, heat engines and refrigerators are provided. Entropy changes that take place during processes for pure substances, incompressible substances and ideal gases are described.

The third part of the course establishes thermodynamic formulations for the calculation of enthalpy, internal energy and entropy as function of pressure and temperature, Gibbs energy, fugacity and chemical potential. Two-phase systems are introduced as well as the use of equations of state to construct the complete phase diagrams of pure fluid.

The final part of the course focuses on the properties of mixtures and the phase behavior of multicomponent systems. The fundamental equations of phase equilibria in terms of the chemical potential and fugacity are also discussed. The concept of an ideal solution is introduced and developed. This is followed by an assessment of non-ideal behavior and the use of activity coefficients for describing phase diagrams. Particular focus is given to phase equilibria. Finally, concepts relating to chemical equilibria are introduced with the general concepts developed being applied to reacting species. Examples here include the calculation of the Gibbs free energy and the equilibrium constant of a reaction.

Resources for the acquisition of material properties and data:

1. NIST Chemistry WebBook (https://webbook.nist.gov/chemistry/)
2. CRC Handbook of Chemistry & Physics, 99th Edition (http://hbcponline.com/)

Method-specific Competencies

Techniques and Technologies: assessed

Decision-making: assessed

Problem-solving: assessed

Critical Thinking: assessed

Personal Competencies

Creative Thinking: assessed

Critical Thinking: assessed

Lecture notes

Lecture handouts, background literature, problem sheets and notes will be made accessible to enrolled students through the lecture Moodle site.

Literature

Although there is not set text for the course, the following three texts will be used in part and are excellent introductions to Chemical Engineering thermodynamics:


Prerequisites / notice

A basic knowledge of chemical thermodynamics is required.

Taugnt competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies: assessed

Method-specific Competencies

Analytical Competencies: assessed

Decision-making: assessed

Problem-solving: assessed

Personal Competencies

Creative Thinking: assessed

Critical Thinking: assessed

ECTS Hours

Mass Transfer 4 credits 2V+2U

Heat Transport and Fluid Dynamics 4 credits 4G

Number Title Type ECTS Hours Lecturers

- Extern Examination Block III

Lecture notes

Lecture notes will be handed out

Notice: This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

This course teaches the basis and the methods for the description and for the quantitative treatment of heat transfer and fluid flow with emphasis on physico-chemical processes at the end of this course students should be familiar with the basics of heat transfer and fluid dynamics, and have acquired the ability to describe these phenomena in practical processes and to perform corresponding calculations.

Mechanisms of heat and momentum transfer; analogy between mass, heat and momentum transfer; dimensional analysis; kinematics and continuum mechanics; steady and non-steady; laminar and turbulent flow; inviscid flows; Bernoulli equation; Navier-Stokes equations; boundary layer theory; steady and non-steady heat conduction; convective heat transfer; heat transfer correlations; radiative heat transfer.
529-0632-00L  Homogeneous Reaction Engineering  O  4 credits  3G  P. Arosio


Objective  Provide to the students a complete methodology for the analysis and design of homogeneous reactors


Lecture notes  Scripts are available on line on the web page of the Arosio group.


752-4001-00L  Microbiology  O  2 credits  2V  M. Ackermann, M. Schuppler, J. Vorholt-Zambelli

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

Objective  Teaching of basic knowledge in microbiology.

Content  Der Schwerpunkt liegt auf den Themen: Bakterielle Zellbiologie, Molekulare Genetik, Wachstumsphysiologie, Biochemische Diversität, Phylogenie und Taxonomie, Prokaryotische Vielfalt, Interaktion zwischen Menschen und Mikroorganismen sowie Biotechnologie.

Lecture notes  Wird von den jeweiligen Dozenten ausgegeben.

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

401-0675-00L  Statistical and Numerical Methods for Chemical Engineers  O  3 credits  2V+2U  R. Käppeli, P. Müller, C.-J. Shih

Abstract  This course covers common numerical algorithms and statistical methods used by chemical engineers to solve typical problems arising in industrial and research practice.

Objective  This course covers common numerical algorithms and statistical methods used by chemical engineers to solve typical problems arising in industrial and research practice. The focus is on application of these algorithms to real world problems, while the underlying mathematical principles are also explained. The MATLAB environment is adopted to integrate computation, visualization and programming.

Content  Topics covered:

Part I: Numerical Methods:
- Interpolation & Numerical Calculus
- Non-linear Equations
- Ordinary Differential Equations
- Partial Differential Equations
- Linear and Non-linear Least Squares

Part II: Statistical Methods:
- Data analysis and regression methods
- Statistical experimental design
- Multivariate analysis

Lecture notes  For the numerics part, see http://www.sam.math.ethz.ch/~karoger/numci/2022/
For the statistics part, see http://stat.ethz.ch/lectures/as22/statistical-numerical-methods.php

Literature  Recommended reading:
4) W. A. Stahel, Statistische Datenanalyse, Vieweg, 4th edition 2002

351-0778-00L  Discovering Management  O  3 credits  3G  B. Clarysse, S. Brunsoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe

Abstract  Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective  The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
(1) broaden understanding of management principles and frameworks
(2) advance insights into the sources of corporate and entrepreneurial success
(3) develop skills to apply this knowledge to real-life managerial problems

The content of the course includes the following:
The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.
The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.
The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes  All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.
Taught competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Problem-solving

Social Competencies

Communication

Self-presentation and Social Influence

Personal Competencies

Creative Thinking

Critical Thinking

Examined in the Spring Semester.

Laboratory Courses and Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

The focus of part I of the case study course lies on the literature-based comparison of chemical process alternatives. Based on this compilation and selected quantitative as well as qualitative measures, a process assessment and comparison is conducted. A basic flowsheet is then generated, and mass and energy balances are performed to carry out a preliminary economic and environmental assessment.

Objective

- to obtain knowledge about different databases and sources of information
- application of the knowledge obtained in lectures to a real problem
- problem-oriented problem solving (application of different methods to the same subject)
- team work
- report writing and presentation techniques

Content

The focus of part I of the case study course lies on the literature-based comparison of chemical process alternatives. For this purpose, relevant substance data (i.e. physico-chemical, toxicological, safety, and environmental data), as well as information about synthesis routes and technical implementations (i.e. on reaction kinetics; possible separation operations; economic, safety, and environmental aspects), are collected from the literature. Based on this compilation and selected quantitative as well as qualitative measures, a process assessment and comparison is conducted and the most promising process alternative is chosen for further evaluation. For this alternative, a basic flowsheet and mass and energy balances are generated.

529-0639-01L Chemical Engineering Laboratory

Abstract

Introduction to various tools of chemical engineering techniques with reference to the lectures. In groups of two, students will conduct experiments in the following areas: thermodynamics and phase equilibria including electrochemistry, transport phenomena, kinetics and selectivity of complex reactions, characterisation of ideal and real reactors.

Objective

Introduction to various tools of chemical engineering techniques with reference to the running lectures.

Content

In groups of two, students will conduct selected experiments in the following areas: thermodynamics and phase equilibria including electrochemistry, transport phenomena, kinetics and selectivity of complex reactions, characterisation of ideal and real reactors.

Prerequisites / notice

Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Languages Courses

see Science in Perspective: Language Courses ETH/UZH

Chemical Engineering Bachelor - Key for Type

<table>
<thead>
<tr>
<th></th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
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</thead>
<tbody>
<tr>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>W+</td>
<td>W</td>
</tr>
<tr>
<td>Courses outside the curriculum</td>
<td>W+</td>
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<tr>
<td>Suitable for doctorate</td>
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Key for Hours

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<tbody>
<tr>
<td>lecture</td>
<td></td>
<td>lecture with exercise</td>
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<td>seminar</td>
<td>colloquium</td>
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<td>P</td>
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<td>A</td>
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<td>R</td>
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<tr>
<td>practical/laboratory course</td>
<td></td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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Special students and auditors need special permission from the lecturers.
### Core Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>857-0001-00L</td>
<td>Methods I: Research Design, Qualitative Methods, and Data Collection</td>
<td>O</td>
<td>6</td>
<td>2U+2S</td>
<td>M. Jacob, F. Schimmelfennig, C. Freudlsperger, M. Nasr</td>
</tr>
</tbody>
</table>

**Abstract**
The seminar covers basic issues of research design, small-n research, and data collection. It deals with issues of causality, conceptualization, case study design and QCA. Data collection includes interviews, surveys, text analysis, and experimental research.

**Objective**
This MACIS core seminar covers basic issues of research design, small-n research, and data collection. It familiarizes students with general research design problems such as defining research questions, analyzing causality, and designing single and comparative case studies. It then introduces them to basic issues in small-n research. Students acquire an understanding of the specific challenges and design problems in qualitative analysis. Finally, students are introduced to exemplary methods of data collection. By the end of the course, students should be able to use the principal methods of data collection used by political scientists; have a critical understanding of the advantages and disadvantages of the methods, and should be able to reflect on and discuss the methods in light of research questions of their interest.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>assessed</td>
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<table>
<thead>
<tr>
<th>Literature</th>
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</thead>
<tbody>
<tr>
<td>see <a href="http://www.cis.ethz.ch/education/macis/courses">http://www.cis.ethz.ch/education/macis/courses</a></td>
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<table>
<thead>
<tr>
<th>W</th>
<th>8 credits</th>
<th>2S</th>
<th>F. Schimmelfennig, D. Kübler</th>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>857-0007-00L</td>
<td>Democracy</td>
<td>W</td>
<td>8</td>
<td>2S</td>
<td>F. Schimmelfennig, D. Kübler</td>
</tr>
</tbody>
</table>

**Abstract**
The seminar focuses on seminal books and articles as well as brand new analyses on topical issues of democratic theory and practice. After reviewing theoretical models and different types of democracy, the seminar deals with core problems of democratic governance and with challenges to democracy stemming from globalization and international institutions.

**Objective**
At the end of the seminar, students are familiar with the relevant theoretical and empirical literature on democracy and democratization in national and international contexts. They are able to reflect on contemporary challenges to democracy, in particular those stemming from the internationalization of politics.

**Taught competencies**

<table>
<thead>
<tr>
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<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<th>8 credits</th>
<th>2S</th>
<th>F. Schimmelfennig, D. Kübler</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>857-0009-00L</td>
<td>Political Violence</td>
<td>W</td>
<td>8</td>
<td>2S</td>
<td>L.-E. Cederman, A. Wenger</td>
</tr>
</tbody>
</table>

**Abstract**
This course offers an introduction to political violence in domestic and international politics. The course covers explanations of interstate wars, theories of civil and ethnic wars and regional conflict. Other topics include new threats, including transnational terrorist networks and other non-state actors, and the relationship between conflict and nation-building and democratization processes.

**Objective**
This course offers an introduction to political violence in domestic and international politics. The course covers explanations of interstate wars, theories of civil and ethnic wars and regional conflict. Other topics include new threats, including transnational terrorist networks and other non-state actors, and the relationship between conflict and nation-building and democratization processes.

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<th>Lecturers</th>
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<tr>
<td>857-0091-00L</td>
<td>Methods II: Quantitative Methods</td>
<td>O</td>
<td>6</td>
<td>2U+2S</td>
<td>D. Hangartner, A. Alrababa'h</td>
</tr>
</tbody>
</table>

**Abstract**
This class provides an introduction to quantitative methods for social science and policy analysis. The class covers statistical inference, introductory probability, descriptive statistics, regression, and statistical and database programming.

**Objective**
After this course, students should be able to assemble a dataset, prepare descriptive statistics, develop and test hypotheses, and present their results in a high-quality presentation or paper.

### Research Seminars

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>857-0103-00L</td>
<td>Topics in Public Policy: Governing the Energy Transition</td>
<td>W</td>
<td>8</td>
<td>2S</td>
<td>S. Sewerin, N. Schmid</td>
</tr>
</tbody>
</table>

**Abstract**
This course addresses the role of policy change and its underlying politics in the transformation of the energy and other climate and sustainability-related sectors. It focuses on political perspectives (while also touching on historical and socio-economic perspectives) and applies various theoretical concepts to understand specific aspects of transition governance.

**Objective**
- To gain an overview of the history of the transition of large socio-technical systems
- To recognize challenges for transformative policy change and to understand the theoretical frameworks and concepts for studying transitions
- To develop own research question and address it in research paper that demonstrates knowledge of the role of policy and politics in transitions
This research seminar complements the MACIS core seminar in Political Economy. It covers topics such as international trade, international security, and climate change. Active participation in the seminar (15%) and the presentation (15%) will form one part of the final grade, with the research paper forming the rest (70%).

**Topics in Public Policy: The Politics and Policies of International Migration**

Number of participants limited to 18. MACIS students are given priority.

Abstract

This seminar introduces the MACIS core seminar in Political Economy. It covers topics such as international trade, environmental policy, international finance, and foreign direct investment, and welfare state policy. Students will be based on reading assignments and discussions in class, develop a research question, present a research design, and write a paper.

Objective

Students will acquire an advanced understanding of some of the key issues and arguments in comparative and international political economy. They will also prepare the ground for a high-quality MA thesis in political economy.

Content

Because the number of students will be very small, the Political Economy core course runs in parallel, and research interests will be heterogeneous, the general approach will be informal and decentralized. Before the seminar starts we will identify what research topics - within the broader field of Comparative and International Political Economy - the participating students are most interested in. In the first two weeks of the semester, we will meet twice for two hours each as a group to discuss how to write a good research seminar paper, and to identify more closely what each student will be working on. Each student will then receive a reading list, so that she/he can get familiar with the state-of-the-art in her/his area of interests and develop a research design in close consultation with Prof. Bernauer and Koubi as well as postdocs from Prof. Bernauer's group. The group as a whole meets again ca. in week 7 of the semester to discuss the provisional research designs. Research then continues in a decentralized fashion - again in consultation with Profs. Bernauer and Koubi as well as postdocs from Prof. Bernauer's group. The group as a whole meets again in the second to last week of the semester. Each student reports on progress in her/his research during that meeting. The research seminar paper must be finalized and submitted by the end of July 2015.

**Introduction to Security Studies**

Number of participants limited to 15. MACIS students are given priority.

Abstract

This seminar introduces students to international security studies research by covering a substantive topic in the field each week (such as war, nuclear weapons, etc.). Students will study the discipline's fundamental questions and will engage with how scholars generate knowledge and derive policy recommendations. Students will study the discipline's fundamental questions, such as why wars occur, if there are ways to make the outbreak of war less likely, and what the advent of nuclear weapons and emergent technologies means for international affairs. The course will also expose students to current debates and research in the field. It will cover how scholars have arrived at their conclusions as well as the various research designs, inferential strategies, and analytical methods they have used. After completing the course, students should have increased familiarity with essential readings in international security studies and the skills to conduct meaningful independent research.

**International Environmental Politics**

This seminar focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective. The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

**International Environmental Politics (with Research Paper)**

Number of participants limited to 18. MACIS students are given priority.

Abstract

This seminar introduces the MACIS core seminar in Political Economy. It covers topics such as international trade, environmental policy, international finance, and foreign direct investment, and welfare state policy. Students will be based on reading assignments and discussions in class, develop a research question, present a research design, and write a paper.

Objective

Students will acquire an advanced understanding of some of the key issues and arguments in comparative and international political economy. They will also prepare the ground for a high-quality MA thesis in political economy.

Content

Because the number of students will be very small, the Political Economy core course runs in parallel, and research interests will be heterogeneous, the general approach will be informal and decentralized. Before the seminar starts we will identify what research topics - within the broader field of Comparative and International Political Economy - the participating students are most interested in. In the first two weeks of the semester, we will meet twice for two hours each as a group to discuss how to write a good research seminar paper, and to identify more closely what each student will be working on. Each student will then receive a reading list, so that she/he can get familiar with the state-of-the-art in her/his area of interests and develop a research design in close consultation with Prof. Bernauer and Koubi as well as postdocs from Prof. Bernauer's group. The group as a whole meets again ca. in week 7 of the semester to discuss the provisional research designs. Research then continues in a decentralized fashion - again in consultation with Profs. Bernauer and Koubi as well as postdocs from Prof. Bernauer's group. The group as a whole meets again in the second to last week of the semester. Each student reports on progress in her/his research during that meeting. The research seminar paper must be finalized and submitted by the end of July 2015.

**Introduction to Security Studies**

Number of participants limited to 15. MACIS students are given priority.

Abstract

This seminar introduces students to international security studies research by covering a substantive topic in the field each week (such as war, nuclear weapons, etc.). Students will study the discipline's fundamental questions and will engage with how scholars generate knowledge and derive policy recommendations. Students will study the discipline's fundamental questions, such as why wars occur, if there are ways to make the outbreak of war less likely, and what the advent of nuclear weapons and emergent technologies means for international affairs. The course will also expose students to current debates and research in the field. It will cover how scholars have arrived at their conclusions as well as the various research designs, inferential strategies, and analytical methods they have used. After completing the course, students should have increased familiarity with essential readings in international security studies and the skills to conduct meaningful independent research.

**Electives**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>860-0023-00L</td>
<td>International Environmental Politics</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>T. Bernauer</td>
</tr>
</tbody>
</table>

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective. The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

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

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

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

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

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Reading materials and slides will be available via Moodle.

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

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

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<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<th>Type</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>857-0027-00L</td>
<td>International Organizations (Field Trip)</td>
<td>2</td>
<td>1S</td>
<td>T. Schmidt</td>
</tr>
<tr>
<td></td>
<td>Only for MA Comparative and International Studies (MACIS).</td>
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</tr>
<tr>
<td>Abstract</td>
<td>A two-day field trip to international organizations in Geneva - e.g., the World Trade Organization, the World Health Organization and the International Committee of the Red Cross.</td>
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<tr>
<td>Objective</td>
<td>Become familiar with the work and challenges of international organizations based in Geneva.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Teams of 2-3 students prepare a 2-3 page background reading for the group on a specific international organization and lead the discussion with representatives of that organization during the visit.</td>
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<tr>
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<th>Type</th>
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<tbody>
<tr>
<td>851-0609-06L</td>
<td>Governing the Energy Transition</td>
<td>2</td>
<td>2V</td>
<td>T. Schmidt</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td></td>
<td>Primarily suited for Master and PhD level.</td>
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<tr>
<td>Abstract</td>
<td>This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.</td>
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<tr>
<td>Objective</td>
<td>- To gain an overview of the history of the transition of large technical systems</td>
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<td></td>
<td>- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions</td>
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<tr>
<td></td>
<td>- To gain knowledge on the role of policy and politics in energy transitions</td>
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<tr>
<td>Content</td>
<td>Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary.</td>
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<tr>
<td></td>
<td>This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derive the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.</td>
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<td></td>
<td>The grade will be determined by a final exam.</td>
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<tr>
<td>Lecture notes</td>
<td>Slides and reading material will be made available via moodle.ethz.ch (only for registered students).</td>
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<tr>
<td>Literature</td>
<td>A reading list will be provided via moodle.ethz.ch at the beginning of the semester.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science &amp; Technology; MSc Environmental Sciences; MSc Management, Technology &amp; Economics; MSc Science, Technology &amp; Policy; ETH &amp; UZH PhD programmes.</td>
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<tbody>
<tr>
<td>865-0064-00L</td>
<td>Decolonizing Aid</td>
<td>2</td>
<td>3G</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td></td>
<td>Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation.</td>
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<tr>
<td></td>
<td>Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted &quot;sur Dossier&quot;.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The course is designed to increase awareness of how cultural perceptions and power structures have influenced society and our understanding of and practice in aid. It promotes alternatives to aid as linear and progressive Eurocentric narrative. The course draws on different theoretical perspectives and scrutinizes practical examples of aid interventions and similar initiatives.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The course goes beyond awareness raising of personal cultural characteristics and recognizing cultural values within development concepts. It unfolds traces of colonialism and power structures in day to day live and the aid industry. It promotes searching and initiating alternatives to aid as a Eurocentric narrative. Participants get familiar with different theoretical perspectives on decoloniality and scrutinize practical examples of aid interventions and similar initiatives.</td>
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<tr>
<td>Content</td>
<td>- Decoloniality key terms and concepts</td>
<td></td>
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<tr>
<td></td>
<td>- Conceptions of and alternatives to development (cooperation)</td>
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<tr>
<td></td>
<td>- Cultural (self-) awareness, diversity</td>
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<tr>
<td></td>
<td>- The role of culture in aid / development cooperation</td>
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<tr>
<td></td>
<td>- Implications of decolonialism for aid policy making and practice</td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit</th>
<th>Type</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>865-0070-00L</td>
<td>The Private Sector and Development Organizations: Building Successful Alliances</td>
<td>1</td>
<td>2G</td>
<td></td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 522 of 2345
Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation. Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted "sur Dossier".

Registration only through the NADEL administration office.

Abstract
The following topics will be discussed: The political economy of the Corporate Social Responsibility discourse, voluntary governance regimes and development: theory of change and effectiveness of soft law approaches, PPPs: introducing concepts and taking stock of experience, analysis of private sector strategies from selected governance actors, engaging with the private sector.

Objective
This course seeks to increase the participants' understanding of the multifaceted and dialectic relationships between civil society, governments and private sector. It equips participants with knowledge and tools required for a strategic interaction between private sector organizations and development agencies. The course enables participants to contribute effectively to policy debates on the role of private sector actors and development.

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL.

---

**Master’s Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>857-0019-00L</td>
<td>Master’s Thesis Colloquium</td>
<td>O</td>
<td>4 credits</td>
<td>3K</td>
<td>J. Spirig</td>
</tr>
</tbody>
</table>

Permission to begin master thesis is required to take part in Colloquium.

Abstract
In this colloquium, students enrolled in the MACIS program first present and discuss research design and methods issues concerning their prospective MA theses. Towards the end of the semester they present preliminary findings from their MA thesis work.

Objective
It is the goal of the colloquium to help students with the initial steps of writing their master theses. During the colloquium, they will develop a relevant research question and hypotheses and select appropriate methods and data.

---

**Comparative and International Studies Master - Key for Type**

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

**Key for Hours**

| V    | lecture                                                                    |
| G    | lecture with exercise                                                      |
| U    | exercise                                                                   |
| S    | seminar                                                                   |
| K    | colloquium                                                                 |
| P    | practical/laboratory course                                               |
| A    | independent project                                                       |
| D    | diploma thesis                                                            |
| R    | revision course / private study                                           |

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Computational Biology and Bioinformatics Master

More information at: https://www.cbb.ethz.ch/

## Core Courses

Please note that the list of core courses is a closed list. Other courses cannot be added to the core course category in the study plan. Also the assignments of courses to core subcategories cannot be changed.

Students need to pass at least one course in each core subcategory.

A total of 40 ECTS needs to be acquired in the core course category.

### Bioinformatics

Please note that all Bioinformatics core courses are offered in the autumn semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0009-00L</td>
<td>Evolutionary Dynamics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+2A</td>
<td>N. Beerenwinkel</td>
</tr>
<tr>
<td>Abstract</td>
<td>Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution. Students should analyze and evaluate models and their application critically and be able to design new models.</td>
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<tr>
<td>Objective</td>
<td>The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.</td>
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<tr>
<td>Content</td>
<td>Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.</td>
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<tr>
<td>Lecture notes</td>
<td>No.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic mathematics (linear algebra, calculus, probability)</td>
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</tbody>
</table>
| Taught competencies | Subject-specific Competencies  
Concepts and Theories  
Problem-solving  
Critical Thinking  
Self-direction and Self-management |  
assessed  
assessed  
assessed  
assessed |
| Method-specific Competencies | Analytical Competencies  
Communication  
Cooperation and Teamwork |  
assessed  
not assessed  
not assessed |
| Social Competencies | not assessed |
| Personal Competencies | not assessed |

| 636-0017-00L | Computational Biology                         | W    | 6    | 3G+2A | T. Vaughan, C. Magnus, T. Stadler |
| Abstract     | The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced. |
| Objective    | Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:  
- stochastic models in molecular evolution  
- phylogenetic & phylodynamic inference  
- maximum likelihood and Bayesian statistics  
Attendees will apply these concepts to a number of applications yielding biological insight into:  
- epidemiology  
- pathogen evolution  
- macroevolution of species  

**Content**  
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer geneologies and phylogenies. Lastly, we introduce the field of phyloynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their applications both on paper and in silico as part of the exercises. |
| Lecture notes| Lecture slides will be available on moodle. |
| Literature   | The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:  
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.  

**Prerequisites / notice**  
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester. |

### Evolutionary Genetics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-6100-00L</td>
<td>Evolutionary Genetics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Evolutionary genetics covers three important areas of modern evolutionary genetics: bioinformatics, molecular evolution and population genetics. Treatment of these three together in a single course provides an integrated education in evolutionary genetics. A solid understanding of these areas is also central to other fields such as conservation biology or behavioural and evolutionary ecology.</td>
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</table>

### Bioinformatics Algorithms

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-6110-00L</td>
<td>Bioinformatics Algorithms</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this lecture, an introduction into main bioinformatics algorithms is provided. We will discuss both &quot;classical&quot; topics such as Hidden Markov Models, Markov chains, phylogenetic trees and &quot;modern&quot; approaches based on sophisticated (deep) learning models. Students can understand the main algorithmic design principles for problems like sequence alignment, motif finding and phylogenetic inference. Further, students get an overview of modern machine learning methods and their applications to bio-medical problems.</td>
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</tbody>
</table>

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 524 of 2345
### Biophysics

#### Former course title: Statistical Methods for the Analysis of Microarray and Short-Read Sequencing Data

#### 401-6282-00L Statistical Analysis of High-Throughput Genomic and Transcriptionomic Data (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: STA426

Mind the enrolment deadlines at UZH: [https://www.uzh.ch/cmsssl/en/studies/application/deadline.html](https://www.uzh.ch/cmsssl/en/studies/application/deadline.html)

**Abstract**

A range of topics will be covered, including basic molecular biology, genomics technologies and in particular, a wide range of statistical and computational methods that have been used in the analysis of DNA microarray and high throughput sequencing experiments.

**Objective**

- Understand the fundamental "scientific process" in the field of Statistical Bioinformatics
- Be equipped with the skills/tools to preprocess genomic data (Unix, Bioconductor, mapping, etc.) and ensure reproducible research (Sweave)
- Have a general knowledge of the types of data and biological applications encountered with microarray and sequencing data
- Have the general knowledge of the range of statistical methods that get used with microarray and sequencing data
- Gain the ability to apply statistical methods/knowledge/software to a collaborative biological project
- Gain the ability to critically assess the statistical bioinformatics literature
- Write a coherent summary of a bioinformatics problem and its solution in statistical terms

**Content**

- Lectures will include: microarray preprocessing; normalization; exploratory data analysis techniques such as clustering, PCA and multidimensional scaling; Controlling error rates of statistical tests (FPR versus FDR versus FWER); limma (linear models for microarray analysis); mapping algorithms (for RNA-Chip-seq); RNA-seq quantification; statistical analyses for differential count data; isoform switching; epigenomics data including DNA methylation; gene set analyses; classification

**Lecture notes**

Lecture notes, published manuscripts

**Prerequisites / notice**

Prerequisites: Basic knowledge of the programming language R, sufficient knowledge in statistics

- Gain the ability to critical assess the statistical bioinformatics literature
- Have the general knowledge of the range of statistical methods that get used with microarray and sequencing data
- Have a general knowledge of the types of data and biological applications encountered with microarray and sequencing data
- Be equipped with the skills/tools to preprocess genomic data (Unix, Bioconductor, mapping, etc.)
- Write a coherent summary of a bioinformatics problem and its solution in statistical terms
- Gain the ability to apply statistical methods/knowledge/software to a collaborative biological project
- Gain the ability to critically assess the statistical bioinformatics literature

- **Number**
  - 262-6106-01L
  - 636-0104-00L

- **Title**
  - Current Topics in Biophysics
  - Biophysical Methods

- **Type**
  - W

- **ECTS**
  - 3G

- **Hours**
  - 6 credits

- **Lecturers**
  - external organisers

- **D. J. Müller**

- **Abstract**

  - Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

  - Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

  - The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

  - The biophysical methods to be taught will include:
    - Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
    - Super resolution optical microscopy: STED, PALM, STORM, other variations
    - Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
    - X-ray, electron and neutron diffraction
    - MRI imaging
    - Scanning tunnelling microscopy and atomic force microscopy
    - Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry

- **Lecture notes**

  Hand out will be given to students at lecture.

- **Literature**

  Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press

- **Prerequisites / notice**

  The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with, under the guidance of the teacher.

#### 529-0004-01L Classical Simulation of (Bio)Molecular Systems

**Number**

- 529-0004-01L

**Title**

- Classical Simulation of (Bio)Molecular Systems

**Type**

- W

**ECTS**

- 4G

**Hours**

- 6 credits

**Lecturers**

- P. H. Hünenberger, J. Dolenc, S. Riniker

**Abstract**

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Objective**

- Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

**Content**

- Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Lecture notes**

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).
The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course provides an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods. 

The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:


Biosystems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td>Abstract</td>
<td>Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear/nonsfernoid ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).</td>
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</tr>
<tr>
<td>Objective</td>
<td>The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.</td>
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</tr>
<tr>
<td>Content</td>
<td>Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label &quot;Systems Biology&quot;, focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td><a href="http://www.csb.ethz.ch/education/lectures.html">http://www.csb.ethz.ch/education/lectures.html</a></td>
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<tr>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0706-00L</td>
<td>Spatio-Temporal Modelling in Biology</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Iber</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on mechanisms and concepts, but mathematical and numerical techniques are introduced as required. Biological examples discussed in the course provide an introduction to key concepts in developmental biology.</td>
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<tr>
<td>Objective</td>
<td>Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system analysis, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.</td>
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<tr>
<td>Lecture notes</td>
<td>All lecture material will be made available online via Moodle.</td>
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</tr>
<tr>
<td>Literature</td>
<td>The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course: Murray, Mathematical Biology, Springer Forgacs and Newman, Biological Physics of the Developing Embryo, CUP Keener and Sneyd, Mathematical Physiology, Springer Fall et al., Computational Cell Biology, Springer Szallasi et al., System Modeling in Cellular Biology, MIT Press Wolkenhauer, Systems Biology Kreyszig, Engineering Mathematics, Wiley</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0117-00L</td>
<td>Mathematical Modelling for Bioengineering and Systems Biology</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Iber</td>
</tr>
<tr>
<td>Abstract</td>
<td>Basic concepts and mathematical tools to explore biochemical reaction kinetics and biological network dynamics.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course covers basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.</td>
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</table>
### Data Science

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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0018-00L</td>
<td>Data Mining I</td>
<td>W</td>
<td>6</td>
<td>3G+2A</td>
<td>K. M. Borgwardt</td>
</tr>
</tbody>
</table>

**Abstract**

Data Mining, the search for statistical dependencies in large databases, is of utmost importance in modern society, in particular in biological and medical research. This course provides an introduction to the key problems, concepts, and algorithms in data mining, and the applications of data mining in computational biology.

**Objective**

The goal of this course is that the participants gain an understanding of data mining problems and algorithms to solve these problems, in particular in biological and medical applications.

**Content**

The goal of the field of data mining is to find patterns and statistical dependencies in large databases, to gain an understanding of the underlying system from which the data were obtained. In computational biology, data mining contributes to the analysis of vast experimental data generated by high-throughput technologies, and thereby enables the generation of new hypotheses.

In this course, we will present the algorithmic foundations of data mining and its applications in computational biology. The course will feature an introduction to popular data mining problems and algorithms, reaching from classification via clustering to feature selection. This course is intended for both students who are interested in applying data mining algorithms and students who would like to gain an understanding of the key algorithmic concepts in data mining.

Tentative list of topics:

1. Distance functions
2. Classification
3. Clustering
4. Feature Selection

**Lecture notes**

Course material will be provided in form of slides.

**Literature**

Will be provided during the course.

**Prerequisites / notice**

Basic understanding of mathematics, as taught in basic mathematics courses at the Bachelor's level.

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### Advanced Machine Learning

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


**Prerequisites / notice**

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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### Systems Genomics

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0101-00L</td>
<td>Systems Genomics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>N. Beerenwinkel, C. Beisel, S. Reddy</td>
</tr>
</tbody>
</table>

**Abstract**

This lecture course is an introduction to Systems Genomics. It addresses how fundamental questions in biological systems are studied and how the resulting data is statistically analyzed in order to derive predictive mathematical models. The focus is on viewing biology from a genomic perspective, which requires high-throughput experimental methods (e.g., RNA-seq, genome-scale screening, single-cell analysis).
The goal of this course is to learn how a detailed quantitative description of genome biology can be employed for a better understanding of molecular and cellular processes and function. Students will learn fundamental questions driving the field of Systems Genomics. They will also be introduced to traditional and advanced state-of-the-art technologies (e.g., CRISPR-Cas9 screening, droplet-microfluidic sequencing, cellular genetic barcoding) that are used to obtain quantitative data in Systems Genomics. They will learn how to use these data to develop mathematical models and efficient statistical inference algorithms to recognize patterns, molecular interrelationships, and systems behavior. Finally, students will gain a perspective of how Systems Genomics can be used for applied biological sciences (e.g., drug discovery and screening, bio-production, cell line engineering, biomarker discovery, and diagnostics).

**Content**

Lectures in Systems Genomics will alternate between lectures on (i) biological questions, experimental technologies, and applications, and (ii) statistical data analysis and mathematical modeling. Selected complex biological systems and the respective experimental tools for a quantitative analysis will be presented. Some specific examples are the use of RNA-sequencing to do quantitative gene expression profiling, CRISPR-Cas9 genome scale screening to identify genes responsible for drug resistance, single-cell measurements to identify novel cellular phenotypes, and genetic barcoding of cells to dissect development and lineage differentiation.

Main Topics:
- Next-generation sequencing
- Transcriptomics
- Biological network analysis
- Functional and perturbation genomics
- Single-cell biology and analysis
- Genomic profiling of the immune system
- Genomic profiling of cancer
- Evolutionary genomics
- Genome-wide association studies

Selected genomics datasets will be analyzed by students in the tutorials using the statistical programming language R and dedicated Bioconductor packages.

**Lecture notes**

The PowerPoint presentations of the lectures as well as other course material relevant for an active participation will be made available online.

**Literature**


**Seminar**

Compulsory seminar.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0704-00L</td>
<td>Computational Biology and Bioinformatics Seminar</td>
<td>O</td>
<td>2 credits</td>
<td>2S</td>
<td>N. Beerenwinkel, K. M. Borgwardt, D. Iber, M. H. Khammash, J. Stelling</td>
</tr>
</tbody>
</table>

The seminar is addressed primarily at students enrolled in the MSc CBB programme. Students of other ETH study programmes interested in Systems Biology are also welcome. Students who want to enrol in the course need to ask the lecturer for permission to enrol in the course.

The seminar will be offered in autumn semester in Basel (involving professors and lecturers from the University of Basel) and in spring semester in Zurich (involving professors and lecturers from the University of Zurich). Professors and lecturers from ETH Zurich are involved in both semesters.

**Abstract**

Computational biology and bioinformatics aim at an understanding of living systems through computation. The seminar combines student presentations and current research project presentations to review the rapidly developing field from a computer science perspective. Areas: DNA sequence analysis, proteomics, optimization and bio-inspired computing, and systems modeling, simulation and analysis.

**Objective**

Studying and presenting fundamental papers of Computational Biology and Bioinformatics. Learning how to make a scientific presentation and how classical methods are used or further developed in current research.

**Content**

Computational biology and bioinformatics aim at advancing the understanding of living systems through computation. The complexity of these systems, however, provides challenges for software and algorithms, and often requires entirely novel approaches in computer science. The aim of the seminar is to give an overview of this rapidly developing field from a computer science perspective. In particular, it will focus on the areas of (i) DNA sequence analysis, sequence comparison and reconstruction of phylogenetic trees, (ii) protein identification from experimental data, (iii) optimization and bio-inspired computing, and (iv) systems analysis of complex biological networks.

The seminar combines the discussion of selected research papers with a major impact in their domain by the students with the presentation of current active research projects / open challenges in computational biology and bioinformatics by the lecturers. Each week, the seminar will focus on a different topic related to ongoing research projects at ETHZ, University of Basel and University of Zurich, thus giving the students the opportunity of obtaining knowledge about the basic research approaches and problems as well as of gaining insight into (and getting excited about) the latest developments in the field.

**Literature**

Original papers to be presented by the students will be provided in the first week of the seminar.

**Advanced Courses**

A total of 30 ECTS needs to be acquired in the Advanced Courses category. Thereof at least 16 ECTS in the Theory and at least 10 ECTS in the Biology category.

Note that some of the lectures are being recorded: https://video.ethz.ch/lectures.html

**Theory**

At least 16 ECTS need to be acquired in this category.

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-0663-00L</td>
<td>Numerical Methods for Computer Science</td>
<td>W</td>
<td>7 credits</td>
<td>2V+2U+2P</td>
<td>R. Hiptmair</td>
</tr>
</tbody>
</table>

The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.
Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently

Content
* Computing with Matrices and Vectors
  2.1 Fundamentals
  2.2 Software and Libraries
  2.4 Computational Effort
  2.5 Machine Arithmetic and Consequences
* Direct Methods for (Square) Linear Systems of Equations
  3.1 Introduction: Linear Systems of Equations (LSE)
  3.2 Theory: Linear Systems of Equations (LSE)
  3.5 Survey: Elimination Solvers for Linear Systems of Equations
  3.7 Sparse Linear Systems
* Direct Methods for Linear Least Squares Problems
  4.1 Least Squares Solution Concepts
  4.2 Normal Equation Methods
  4.3 Orthogonal Transformation Methods
  4.3.1 Transformation Idea
  4.3.2 Orthogonal/Unitary Matrices
  4.3.3 QR-Decomposition
  4.3.4 QR-Based Solver for Linear Least Squares Problems
  4.4 Singular Value Decomposition (SVD)
  4.5 SVD-Based Optimization and Approximation
* Filtering Algorithms
  5.1 Filters and Convolutions
  5.2 Discrete Fourier Transform (DFT)
  5.3 Fast Fourier Transform (FFT)
* Machine Learning of One-Dimensional Data (Data Interpolation and Data Fitting in 1D)
  6.1 Abstract Interpolation (AI)
  6.2 Global Polynomial Interpolation
  6.4 Splines
  6.7 Least Squares Data Fitting
* Iterative Methods for Non-Linear Systems of Equations
  9.2 Iterative Methods
  9.4 Finding Zeros of Scalar Functions
  9.5 Newton's Method in Rn
  9.7 Non-linear Least Squares

Lecture notes
Lecture materials (PDF documents and codes) will be made available to the participants through the course web page and online repositories. Access information will be communicated in the beginning of the course.

Literature
M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002
P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves, in case they do not know it already.

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving
Project Management

263-5210-00L
Probabilistic Artificial Intelligence
W 8 credits 3V+2U+2A A. Krause

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.
Introduction to Mathematical Optimization

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

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

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

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

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

---

Linear System Theory

**Abstract**
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

**Objective**
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

**Content**
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Lecture notes**
Available on the course Moodle platform.

**Prerequisites / notice**
Sufficient mathematical maturity, in particular in linear algebra, analysis.

---

Signals and Systems

**Abstract**
Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

**Objective**
Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

**Content**

**Lecture notes**
Lecture notes available on course website.

**Prerequisites / notice**
Control Systems I is helpful but not required.

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Concepts of Object-Oriented Programming

**Abstract**
Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection

**Objective**
After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.

**Content**
The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

**Literature**
Will be announced in the lecture.

**Prerequisites / notice**
Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

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Random Processes: Theory and Applications from Physics to Finance

**Abstract**
Basics of probability theory; Random processes: General concepts; Markov processes: Master equation, Fokker-Planck equation, stochastic differential equations; Mathematical finance

**Objective**
Basics of the theory of stochastic processes and an overview of selected applications

---

Programming for Life Sciences

**Abstract**
This course aims to train the students into the proficient use of programming in analyzing data derived from projects in life sciences. The format of the course includes 2 hour lectures in which notions of software design and engineering will be discussed, and programming projects, done both in groups as well as individually.
By the end of the course, students should be comfortable with accessing and analyzing a wide variety of biological data. Concepts such as reproducibility, modularity, interoperability, and scalability will be emphasized.

### 636-0015-00L An Introduction to Probability Theory and Stochastic Processes with Applications to Biology

**W** 4 credits 3G

**Abstract**

Biology is becoming increasingly quantitative and mathematical modeling is now an integral part of biological research. In many biological processes, ranging from gene-expression to evolution, randomness plays an important role that can only be understood using stochastic models. This course will provide the students with a theoretical foundation for developing such stochastic models and analyzing phenomena. Throughout the course, several biological applications will be discussed and students will be encouraged to do additional reading based on their research interests.

**Objective**

The aim of this course is to introduce certain topics in Probability Theory and Stochastic Processes that have been specifically selected with an eye on biological applications. This course will teach students the tools and techniques for modeling and analyzing random phenomena. The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has efficiently and consistently.

The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.

**Content**

The first half of the course will cover the basics of Probability Theory while the second half will delve into the theory of Stochastic Processes. Below is the list of topics that will be covered in the course.

1. The mathematical representation of random phenomena: The probability space, properties of the probability measure, Independence of events, Conditional probability and Bayes formula, applications to parameter inference.


3. Convergence of Random Variables: Modes of convergence, Laws of large numbers, the central limit theorem, the law of the iterated logarithm, Applications to the analysis of cell population data.


### Literature

While no specific textbook will be followed, much of the material and homework problems will be taken from the following books:


### Prerequisites / notice

The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.

### 263-3010-00L Big Data

**W** 10 credits 3V+2U+4A G. Fourny

**Abstract**

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

This combination of requirements, together with the technologies that have emerged in order to address them, is typically referred to as “Big Data.” This revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
Objective

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. **Explain, in the big picture, how a relational database works and what it can do in your own words.**
2. **Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).**
3. **Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.**
4. **Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality**
5. **Explain what bad design is and why it matters.**
6. **Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".**
7. **Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.**
8. **Access an existing relational database from a host language such as Java, using bridges such as JDBC.**
9. **Explain what data independence is all about and didn't age a bit since the 1970s.**
10. **Explain, in the big picture, how a relational database is physically implemented.**
11. **Know and deal with the natural syntax for relational data, CSV.**
12. **Explain the data cube model including slicing and dicing.**
13. **Store data cubes in a relational database.**
14. **Map cube queries to SQL.**
15. **Slice and dice cubes in a UI.**

And of course, you will think that tables are the most wonderful object in the world.

Content

**Using a relational database**

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

**Taking a relational database to the next level**

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

**Analytics on top of a relational database**

12. Data cubes

**Outlook**

13. Outlook

**Literature**

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

**Prerequisites / notice**

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

**752-5500-00L Applied Bioinformatics: Microbiomes**

**Abstract**

Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.
Prerequisites / notice
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (UNIX/bash and/or Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers (students without a laptop should consult with their department’s ISG group).

All software used in the course is free and open-source. Installation instructions will be provided to students prior to the start of the course.

Biology
At least 10 ECTS need to be acquired in this category.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>529-0733-01L</td>
<td>Chemical Biology and Synthetic Biochemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>K. Lang</td>
</tr>
<tr>
<td>Abstract</td>
<td>Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme-catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.</td>
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<tr>
<td>Objective</td>
<td>Overview of enzymes, enzyme-catalyzed reactions and metabolic processes.</td>
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</tr>
<tr>
<td>Content</td>
<td>Principles of enzymatic catalysis, enzyme kinetics, mechanisms of enzyme catalyzed reactions (group transfer reactions, carbon-carbon bond formation, eliminations, isomerisations and rearrangements), cofactor chemistry, enzymes in organic synthesis and the biosynthesis of natural products, catalytic antibodies.</td>
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<tr>
<td>Literature</td>
<td>Citations from the original literature relevant to the individual lectures will be assigned during the lectures.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>A script will not be handed out.</td>
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<td>Taught competencies</td>
<td>Subject-specific Competencies: Concepts and Theories, assessed</td>
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<td></td>
<td>Techniques and Technologies, assessed</td>
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<td>Cooperation and Teamwork, not assessed</td>
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<td>Customer Orientation, not assessed</td>
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<td>Leadership and Responsibility, not assessed</td>
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<td>Self-awareness and Self-reflection, not assessed</td>
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<td></td>
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<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
<tr>
<td>Abstract</td>
<td>Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<tr>
<td>Objective</td>
<td>This course focuses on the concepts of classical and modern genetics and genomics.</td>
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<tr>
<td>Content</td>
<td>The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<tr>
<td>Lecture notes</td>
<td>Scripts and additional material will be provided during the semester.</td>
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<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
<tr>
<td>Abstract</td>
<td>Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Objective</td>
<td>This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Content</td>
<td>Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Literature</td>
<td>Updated handouts will be provided during the class.</td>
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<td>English</td>
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<td>The lecture &quot;Grundlagen der Biologie II: Mikrobiologie&quot; is the basis for this advanced lecture.</td>
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<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
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<tr>
<td>Abstract</td>
<td>Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.</td>
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<tr>
<td>Objective</td>
<td>Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.</td>
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</table>
Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

- Published works
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<td>Adaptability and Flexibility</td>
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<tr>
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<td>Decision-making</td>
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<tr>
<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>Integrity and Work Ethics</td>
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<tr>
<td>not assessed</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Self-awareness and Self-reflection</td>
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<tr>
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<td>Project Management</td>
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<td>Negotiation</td>
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</tbody>
</table>

636-0105-00L Introduction to Biological Computers

W 4 credits

Y. Benenson

Abstract
Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanothechnology and synthetic biology.

Objective
The course has the following objectives:

* Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms

* Introduce basic theories of computation

* Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include
- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly

* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations

* Foster creativity, research and communication skills through semester-long "Design challenge“ assignment in the broad field of biological computing and biological circuit engineering.

Autumn Semester 2022
Content

Note: the exact subjects can change, the details below should only serve for general orientation

Lecture 1. Introduction: what is molecular computation (part I)?

* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines

1st hour

* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour

* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation

* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4. Classical DNA computing

* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly

* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes

* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits

* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I

* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II

* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I

* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II

* RNAi logic circuits
* RNAi-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits

* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics

* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
This course will describe the structure and function of the eukaryotic nucleus. In this course, all features of the nucleus from regulated import/export through pores, to the compartmentalization of transcription, splicing, replication and repair will be covered. The lecture will illustrate a way of thinking rather than attempt to cover single details of the issues discussed.

Molecular Mechanisms of Development

This lecture will present examples for developmental switches in a variety of systems, including single-cell organisms, plants, nematodes, flies and vertebrates. The lecture will illustrate a way of thinking rather than attempt to cover single details of the issues discussed.

Molecular Control of Vertebrate Development and Organogenesis

This course will introduce the participants to the basic principles, genetic tools and vertebrate model systems used to study developmental processes.

Evolutionary Medicine: Morphological Changes and Pathologies (University of Zurich)

This course addresses aspects of this transdisciplinary research in lectures and provides opportunity to perform small research projects in the fields of paleogenetics, palaeopathology, imaging technologies, long- and short-term morphological changes.

Functional Organization of the Cell Nucleus

This course will describe the structure and function of the eukaryotic nucleus. In this course, all features of the nucleus from regulated import/export through pores, to the compartmentalization of transcription, splicing, replication and repair will be covered. The lectures will give an up-to-date overview of a complex structure-function problem that touches on crucial aspects of cell identity.

Cellular Signalling

This course gives an introduction into cellular signalling mechanisms, followed by specific topics covering tyrosine/threonine kinase growth factor receptors, protein/protein and protein/lipid interaction modules, signalling by Ras family G proteins, lipid kinases, phospholipid-coupled transduction systems, protein kinase C, G protein-coupled receptors, and other topics.

Frontiers in RNA Biology

The lecture will cover the following topics: chemistry and structure of RNA; major classes of cellular RNAs, chemistry and structure of RNA; pre-mRNA processing with emphasis on splicing and polyadenylation; biogenesis of tRNA and rRNA; biochemistry and function of RNA interference (RNAi) and microRNAs; RNA trafficking in the cell, RNA quality control and RNA degradation; and more.

Stem Cells: Biology and Therapeutic Manipulation

Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to

### Objective
Subject specific skills:
- o describe basic evolutionary theory and its applications
- o critically assess the presentation of evolutionary research in the popular media

### Content
This course will provide a broad overview of current evolutionary thought, including the mechanisms of evolutionary change,

### Literature
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

### Lab Rotations
Students starting before Autumn Semester 2021:
- 18 ECTS in total (262-01*).
- At least two lab rotations need to be completed in two different research groups (supervisors).
- Either choose Lab Rotation Short 1 (6 ECTS), Lab Rotation Short 2 (6 ECTS) and Lab Rotation Short 3 (6 ECTS)
- Or choose Lab Rotation Long 1 (9 ECTS) and Lab Rotation Long 2 (9 ECTS)
- Or choose Lab Rotation Short 1 (6 ECTS) and Industry Internship (12 ECTS)
- Or choose Lab Rotation Short 1 (6 ECTS) and Lab Rotation Long 3 (12 ECTS)
### Science in Perspective

- **see Science in Perspective: Type A: Enhancement of Reflection Capability**

- **Recommended Science in Perspective (Type B) for D-BSE**

- **see Science in Perspective: Language Courses ETH/UZH**

### Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>262-0800-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Professors</td>
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</table>

*Only students who fulfill the following criteria are allowed to begin with their master thesis:
  a. successful completion of the bachelor programme;
  b. fulfilling of any additional requirements necessary to gain admission to the master programme.*
Abstract
The Master Thesis is the result of an independent scientific research and/or constructive development project in the chosen area of specialization.

Objective
The Master thesis concludes the Master programme. By writing up the Master thesis, students show their ability to independently produce a coherent and scientific piece of work.

Content
The program concludes with a Master thesis that includes a written report and an oral presentation. The topic of the thesis can be chosen according to the student's interests in the field of computational biology & bioinformatics.

Prerequisites / notice
The duration for the master's thesis in the study regulation 2017 (per Autumn Semester 2021) is 24 working weeks (thereof, 2 weeks are reserved for compensation of public holidays, sick leave and other unplanned short term absences.)

Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0002-AAL</td>
<td>Data Structures and Algorithms</td>
<td>E-</td>
<td>8 credits</td>
<td>15R</td>
<td>F. O. Friedrich Wicker</td>
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<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course is about fundamental algorithm design paradigms (such as induction, divide-and-conquer, backtracking, dynamic programming), classic algorithmic problems (such as sorting and searching), and data structures (such as lists, hashing, search trees). Moreover, an introduction to parallel programming is provided. The programming model of C++ will be discussed in some depth.

Objective
An understanding of the design and analysis of fundamental algorithms and data structures. Knowledge regarding chances, problems and limits of parallel and concurrent programming. Deeper insight into a modern programming model by means of the programming language C++.

Content
Fundamental algorithms and data structures are presented and analyzed. Firstly, this comprises design paradigms for the development of algorithms such as induction, divide-and-conquer, backtracking and dynamic programming and classical algorithmic problems such as searching and sorting. Secondly, data structures for different purposes are presented, such as linked lists, hash tables, balanced search trees, heaps and union-find structures. The relationship and tight coupling between algorithms and data structures is illustrated with geometric problems and graph algorithms.

In the part about parallel programming, parallel architectures are discussed conceptually (multicore, vectorization, pipelining). Parallel programming concepts are presented (Amdahl's and Gustavson's laws, task/data parallelism, scheduling). Problems of concurrency are analyzed (Data races, bad interleavings, memory reordering). Process synchronisation and communication in a shared memory system is explained (mutual exclusion, semaphores, monitors, condition variables). Progress conditions are analysed (freedom from deadlock, starvation, lock- and wait-freedom). The concepts are underpinned with examples of concurrent and parallel programs and with parallel algorithms.

The programming model of C++ is discussed in some depth. The RAII (Resource Allocation is Initialization) principle will be explained. Exception handling, functions and lambda expression and generic programming with templates are further examples of this part. The implementation of parallel and concurrent algorithm with C++ is also part of the exercises (e.g. threads, tasks, mutexes, condition variables, promises and futures).

Literature

Prerequisites / notice
Prerequisites:
Lecture Series 252-0835-00L Informatik I or equivalent knowledge in programming with C++.

Please note that this is a self study (virtual) course, which implies that (in the autumn semester) there are no physical lectures or exercise sessions offered. If you want to attend the real course, please go to 252-0002-00L in the spring semester.

252-0856-AAL | Computer Science | E-    | 4 credits | 9R    | F. O. Friedrich Wicker, R. Sasse |
|              | Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. |      |      |       |                    |

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Objective
Primäres Lernziel der Vorlesung ist die Befähigung zum Programmiern mit C++. Studenten beherrschen nach erfolgreichem Abschluss der Vorlesung die Mechanismen zum Erstellen eines Programms, sie kennen die fundamentalen Kontrollstrukturen, Datenstrukturen und verstehen, wie man ein algorithmisches Problem in ein Programm abbildet. Sie haben eine Vorstellung davon, was "hinter den Kulissen" passiert, wenn ein Programm überprüft und ausgeführt wird.

Content

Lecture notes
Ein Skript in englischer Sprache wird semesterbegleitend herausgegeben. Das Skript und die Folien werden auf der Vorlesungshomepage zum Herunterladen bereitgestellt.

Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010

406-0603-AAL | Stochastics (Probability and Statistics) | E-    | 4 credits | 9R    | M. Kalisch |
|              | Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. |      |      |       |                    |

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Cell and Molecular Biology for Engineers I and II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics: DNA, chromosomes, RNA, protein, genetics, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer, development and stem cells.

Literature

Bio V: Bioinformatics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Bioinformatics is the application of computational methods to interpret and analyze biological data. It combines knowledge from computer science, statistics, mathematics, and biology.

Objective
After completing this course, students will understand fundamental concepts and methods of bioinformatics, be able to apply these concepts to the analysis of large data sets, and be aware of the ethical issues in this field.

Content
The course will cover topics such as sequence alignment, multiple sequence alignments, motifs, phylogenetic trees, protein structure prediction, and gene expression analysis.

Literature
Pevsner J, Bioinformatics and Functional Genomics, 3rd edition, 2015, chapters 1–7

Computational Biology and Bioinformatics Master - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Eligibility</th>
<th>Notes</th>
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</thead>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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Key for Hours

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<td>U</td>
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<td>A</td>
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<td>S</td>
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<tr>
<td>K</td>
<td>colloquium</td>
<td>R</td>
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</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Cyber Security Master

► Field of Specialization

►► Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>D. Basin, M. Ochoa Ronderos</td>
</tr>
</tbody>
</table>

Abstract
Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

Objective
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

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The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include
- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security

252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde

Abstract
The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

The first part of the lecture covers individual system's aspects starting with tamperproof or tamperresistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include; patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

### 263-4640-00L Network Security
- **W 8 credits**
- **2V+2U+3A**
- **A. Perrig, S. Frei, M. Legner, K. Paterson**

#### Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

#### Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

#### Content
The course will cover topics spanning four broad themes with a focus on the first two themes:

1. **Network defense mechanisms** such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. **Network attacks** such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. **Analysis and inference topics** such as traffic monitoring and network forensics; and
4. **New technologies** related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

#### Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

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

#### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0575-00L</td>
<td>Advanced Topics in Communication Networks</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>L. Vanbever, R. Jacob</td>
</tr>
</tbody>
</table>

#### Abstract
This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover advanced topics in Internet routing and forwarding.

#### Objective
The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.
The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control), network security (network virtualization, network programmability), and system security (network programmability (OpenFlow, P4), network measurements).

The course will be divided into two main blocks. The first block (~8 weeks) will interleave classical lectures with practical exercises and labs. The second block (~6 weeks) will consist of a practical project which will be performed in small groups (~3 students). During the second block, lecture slots will be replaced by feedback sessions where students will be able to ask questions and get feedback about their project. The last week of the semester will be dedicated to student presentations and demonstrations.

Lecture notes
Lecture notes and material will be made available before each course on the course website.

Literature
Prerequisites: Communication Networks (227-0120-00L) or equivalents / good programming skills (in any language) are expected as both the exercises and the final project will involve coding.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>assessed</td>
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<td>assessed</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<td>Creative Thinking</td>
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<td>assessed</td>
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<td>assessed</td>
<td>Critical Thinking</td>
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</table>

227-0579-00L

Hardware Security

Abstract
This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.

Objective
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:
- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.
- writing critical reviews and constructive discussions with peers on this topic.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature
Prerequisites / notice
Slides, relevant literature and manuals will be made available during the course.

Experience with Linux, systems programming and computer architecture.

252-0811-00L

Applied Security Laboratory

Number of participants limited to 48.

Abstract
Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

Objective
The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, logging), application security with an emphasis on web applications (web server setup, common web exploits, authentication, session handling, code security), computer forensics, and risk analysis and risk management.

Content
This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectiveness and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.

Lecture notes

Literature
Recommended reading includes:
- Garfinkel, Schwartz; Spafford: Practical Unix & Internet Security, O'Reilly & Associates.
- Various: OWASP Guide to Building Secure Web Applications, available online
- O'Reilly, Loukides: Unix Power Tools, O'Reilly & Associates.
- Frisch: Essential System Administration, O'Reilly & Associates.
- NIST: Risk Management Guide for Information Technology Systems, available online as PDF
- BSI: IT-Grundschutzhandbuch, available online
The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in security protocols, multi-hop networks, recent advances in security of multi-hop networks, and RFID privacy challenges and solutions.

The seminar covers various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.

**Seminar**

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-4601-00L</td>
<td>Current Topics in Information Security</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>S. Capkun, K. Paterson, A. Perrig, S. Shinde</td>
</tr>
</tbody>
</table>

The seminar covers various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.

**Semester Project**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>260-0100-00L</td>
<td>Semester Project</td>
<td>W</td>
<td>12 credits</td>
<td>26A</td>
<td>Professors</td>
</tr>
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</table>

The Semester Project provides students with the opportunity to apply acquired knowledge and skills. The students can gain hand-on experience by solving independently a technical-scientific problem.

**Minor**

- To understand what it means for a zero-knowledge proof to be secure
- To construct and analyse various types of zero-knowledge proofs
- To understand some applications of zero-knowledge proofs
- To construct and analyse various types of zero-knowledge proofs
- To understand some applications of zero-knowledge proofs

Selected Topics
- security protocols: models, specification & verification
- trust management, access control and non-interference
- side-channel attacks
- identity-based cryptography
- host-based attack detection
- anomaly detection in backbone networks
- key-management for sensor networks

The reading list will be published on the course web site.

**Prerequisites**

* The lab allows flexible working since there are only few mandatory meetings during the semester.
* The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas: information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.
* Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the recommended requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.
* All participants must sign the lab's charter and usage policy during the introduction lecture.

**252-1411-00L** Security of Wireless Networks

**Abstract**

Core Elements: Communication channel, Wireless network architectures and protocols, attacks on wireless networks, protection techniques.

**Objective**

After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.

**Content**


**263-4655-00L** Zero-Knowledge Proofs

**Abstract**

Zero-knowledge proofs are protocols which allow a prover to convince a verifier that a statement is true without leaking any information beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.

**Objective**

- To understand what it means for a zero-knowledge proof to be secure
- To construct and analyse various types of zero-knowledge proofs
- To understand some applications of zero-knowledge proofs

**Content**

The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in cryptography and the real world. The course may also describe some more advanced constructions of non-interactive proofs.

**Prerequisites**

Students should have taken a first course in Cryptography (as taught in the Information Security course at Bachelor's level). Experience with algebra and probability is desirable.

**Semester Project**

The Semester Project provides students with the opportunity to apply acquired knowledge and skills. The students can gain hand-on experience by solving independently a technical-scientific problem.

**Prerequisites**

At least one core course in Cyber Security and one inter focus course must have been completed successfully.
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective:

**Big Data**


**Lecturers**

G. Alonso

The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

**Objective**

The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

**Abstract**

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.

This combination of requirements, together with the technologies that have emerged in order to address them, is typically referred to as "Big Data." This revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

The course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBLR, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.


Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

**Prerequisites / notice**

This course, in the autumn semester, is only intended for:

- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:

- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021
- "Information Systems for Engineers" (SQL, relational databases): this Fall

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

Subject-specific Competencies

### Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
<tr>
<td>Abstract</td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
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<tr>
<td>Objective</td>
<td>Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.</td>
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<tr>
<td>Content</td>
<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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<tr>
<td>Lecture notes</td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least &quot;Introduction to Machine Learning&quot; or an equivalent course offered by another institution.</td>
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<td>PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.</td>
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<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>S. Capkun, S. Shinde</td>
</tr>
<tr>
<td>Abstract</td>
<td>The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.</td>
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<tr>
<td>Objective</td>
<td>In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.</td>
<td></td>
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<tr>
<td>Content</td>
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<td>In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, drtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).</td>
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<td>Along the lectures, model cases will be elaborated and evaluated in the exercises.</td>
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<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>W</td>
<td>9</td>
<td>3V+2U+3A</td>
<td>T. Hoefler, M. Püschel</td>
</tr>
<tr>
<td>Abstract</td>
<td>Advanced topics in parallel and high-performance computing.</td>
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</table>
Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses “Parallele Programmierung (parallel programming)” and “Algorithmen und Datenstrukturen (algorithm and data structures)” or equivalent courses.

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz.

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is to provide an understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
- Advanced Machine Learning https://ml2.inf.ethz.ch/courses/aml/
- Computational Intelligence Lab http://da.inf.ethz.ch/teaching/2019/CIL/
- Statistical Learning Theory http://mi2.inf.ethz.ch/lectures/slt/
- Probabilistic Artificial Intelligence https://las.inf.ethz.ch/teaching/pai-f18

263-3850-00L Informal Methods W 5 credits 2G+2A D. Cock

Abstract
Formal methods are increasingly a key part of the methodological toolkit of systems programmers - those writing operating systems, databases, and distributed systems. This course is about how to apply concepts, techniques, and principles from formal methods to such software systems, and how to get into the habit of thinking formally about systems design even when writing low-level C code.

Objective
This course is about equipping students whose focus is systems with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers. By the end of the course, students should be able to seamlessly integrate basic concepts from formal methods into how they conceive, design, implement, reason about, and debug computer systems.

The goal is not to provide a comprehensive introduction to formal methods - this is well covered by other courses in the department. Instead, it is intended to provide students in computer systems (who may or may not have existing background knowledge of formal methods) with a basis for applying formal methods in their work.

Content
This course does not assume prior knowledge of formal methods, and will start with a quick review of topics such static vs. dynamic reasoning, variants and invariants, program algebra and refinement, etc. However, it is strongly recommended that students have already taken one of the introductory formal methods course at ETH (or equivalents elsewhere) before taking this course - the emphasis is on reinforcing these concepts by applying them, not to teach them from scratch.

Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified seL4 microkernel will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).

Machine Intelligence

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

---

**263-3210-00L Deep Learning**

**Abstract**
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

**Prerequisites / notice**
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  1. Advanced Machine Learning
  2. Computational Intelligence Lab
  3. Introduction to Machine Learning
  4. Statistical Learning Theory
  5. Computational Statistics

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**263-5210-00L Probabilistic Artificial Intelligence**

**Abstract**
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.
**E elective Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
</tr>
<tr>
<td>Abstract</td>
<td>Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.</td>
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<tr>
<td>Objective</td>
<td>Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.</td>
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<tr>
<td>Content</td>
<td>The course is split into 3 parts:</td>
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<td></td>
<td>Robustness in Deep Learning</td>
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<td></td>
<td>- Adversarial attacks and defenses on deep learning models.</td>
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<td></td>
<td>- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).</td>
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<td></td>
<td>- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).</td>
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<tr>
<td>Privacy of Machine Learning</td>
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<td></td>
<td>- Threat models (e.g., stealing data, poisoning, membership inference, etc.).</td>
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<td></td>
<td>- Attacking federated machine learning (across modalities such as vision, natural language and tabular).</td>
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<td>- Differential privacy for defending machine learning.</td>
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<td>- Enforcing regulations with guarantees (e.g., via provable data minimization).</td>
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<tr>
<td>Fairness of Machine Learning</td>
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<td></td>
<td>- Introduction to fairness (motivation, definitions).</td>
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<td></td>
<td>- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).</td>
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<tr>
<td></td>
<td>- Enforcing group fairness with guarantees.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in &quot;Intro to ML&quot; classes at most institutions (e.g., &quot;Introduction to Machine Learning&quot; at ETH).</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies: Concepts and Theories assessed</td>
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<tr>
<td></td>
<td>Method-specific Competencies: Techniques and Technologies assessed, Analytical Competencies assessed, Problem-solving assessed, Creative Thinking assessed, Critical Thinking assessed</td>
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<tr>
<td>252-3005-00L</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7 credits</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<tr>
<td>Objective</td>
<td>The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.</td>
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<tr>
<td>Content</td>
<td>This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<tr>
<td>Literature</td>
<td>Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.</td>
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<tr>
<td>263-5005-00L</td>
<td>Artificial Intelligence in Education</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>M. Sachan, T. Sinha</td>
</tr>
<tr>
<td>Abstract</td>
<td>Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.</td>
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<tr>
<td>Objective</td>
<td>The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.</td>
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<tr>
<td>Content</td>
<td>The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture slides will be made available at the course Web site.</td>
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</tbody>
</table>
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website. There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5255-00L</td>
<td>Foundations of Reinforcement Learning</td>
<td>5</td>
<td>Does not take place this semester.</td>
</tr>
<tr>
<td>263-5300-00L</td>
<td>Guarantees for Machine Learning</td>
<td>7</td>
<td></td>
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<tr>
<td>263-5353-00L</td>
<td>Philosophy of Language and Computation</td>
<td>5</td>
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</table>

**Objective**

By the end of the course, students will be able to:

- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on this topic.

**Content**

Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

**Abstract**

The course will be offered again in FS23.

**Lecture notes**

Lecture notes will be posted on Moodle.

**Literature**

- Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
- Algorithms for Reinforcement Learning, Csaba Czepesvári.

**Prerequisites / notice**

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

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**Guarantees for Machine Learning**

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to:

- Understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- Critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- Effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.
- Outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project

**Content**

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- Concentration bounds
- Uniform convergence and empirical process theory
- Regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- High-dimensional learning
- Computational and statistical learnability (information-theoretic, PAC, SQ)
- Overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- How overparameterized models generalize (statistically and converge computationally)
- Complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- Generalization of robust learning (adversarial or distribution-shift robustness)
- Private and fair learning

**Prerequisites / notice**

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

**Taugt competencies**

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Assessed</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**Philosophy of Language and Computation**

Understand the philosophical underpinnings of language-based artificial intelligence.
This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data.

The goals of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve these.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Randomized Algorithms are algorithms that “flip coins” to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Randomized algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensible to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

The course will cover:
- Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Topics covered in the lecture include:

Lecture notes:
No lecture notes, but slides will be made available on the course webpage.


The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### 252-1425-00L

**Title:** Geometry: Combinatorics and Algorithms

**Type:** W

**ECTS:** 8

**Hours:** 3V+2U+2A

**Lecturers:** B. Gärtner, E. Welzl, M. Hoffmann

**Abstract**

Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

**Objective**

The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains.

In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

**Content**

Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in $\mathbb{R}^d$, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

**Prerequisites / notice**

### Lecture notes

Yes

**Literature**


**Outlook:** In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

![E elective Courses](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)
### Guarantees for Machine Learning

**W 7 credits 3V+1U+2A  F. Yang, A. Sanyal**

**Number of participants limited to 30.**

### Abstract

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

### Objective

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

### Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

### Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH).

### Taught competencies

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

**Method-specific Competencies**

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

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**Visual and Interactive Computing**

**Core Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 555 of 2345
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods.

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including physics-based simulation, computer vision, human machine interaction, and gaming technology.

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve these.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

The course is designed to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

In addition to the lectures, the course includes student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are loosely defined and can include proof-of-concept vision/graphics/HMI research, apps that support teaching with interactive augmented reality, or games that support research and learning. The development platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

### Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>W</td>
<td>5</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
</tr>
<tr>
<td></td>
<td>The goal of this course is an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.</td>
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<tr>
<td></td>
<td>The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality. Topics include: [ - ] Good programming skills (C# / C++ / Java etc.) [ - ] Computer graphics / vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.</td>
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<td></td>
<td>Prerequisites include:</td>
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<td></td>
<td>- Good programming skills (C# / C++ / Java etc.)</td>
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<td></td>
<td>- Computer graphics / vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.</td>
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</tbody>
</table>

### Interfocus Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0006-00L</td>
<td>Algorithms Lab</td>
<td>W</td>
<td>8</td>
<td>4P+3A</td>
<td>A. Steger, E. Welzl</td>
</tr>
<tr>
<td></td>
<td>Only for master students!</td>
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<tr>
<td></td>
<td>Students learn how to solve algorithmic problems given by a textual description (understanding problem setting, finding appropriate modeling, choosing suitable algorithms, and implementing them). Knowledge of basic algorithms and data structures is assumed; more advanced material and usage of standard libraries for combinatorial algorithms are introduced in tutorials.</td>
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<tr>
<td></td>
<td>The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, CGAL, and BGL).</td>
<td></td>
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</tbody>
</table>

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Literature


263-0009-00L Information Security Lab

W 8 credits 2V+1U+3P+1A K. Paterson, D. Basin, S. Capkun, D. Hofheinz, A. Perrig, S. Shinde

Abstract
This InterFocus Course will provide a broad, hands-on introduction to Information Security, introducing adversarial thinking and security by design as key approaches to building secure systems.

Objective
This course will introduce key concepts from Information Security, both from attack and defence perspectives. Students will gain an appreciation of the complexity and challenge of building secure systems.

Content
The course is organised in two-week segments. In each segment, a new concept from Information Security will be introduced. The overall scope will be broad, including cryptography, protocol design, network security, system security.

Lecture notes
Will be made available during the semester.

Literature
Paul C. van Oorschot, Computer Security and the Internet: Tools and Jewels.
Dan Boneh and Victor Shoup, A Graduate Course in Applied Cryptography.

Prerequisites / notice
Ideally, students will have taken the D-INFK Bachelors course “Information Security” or an equivalent course at Bachelors level.

► Free Electives

All Master level courses offered by ETH Zurich, EPF Lausanne and the University of Zurich may be chosen.

Course Catalogue of ETH Zurich

► Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability
Recommended Science in Perspective (Type B) for D-INFK
see Science in Perspective: Language Courses ETH/UZH

► Internship

Number Title Type ECTS Hours Lecturers
260-0700-00L Internship E- 0 credits external organisers
Only for Cyber Security MSc

Abstract
An Internship provides opportunities to gain experience in an industrial environment and it creates a network of contacts.

► Master's Thesis

Number Title Type ECTS Hours Lecturers
260-0800-00L Master's Thesis O 30 credits 64D Professors
Only students who fulfill the following criteria are allowed to begin with their master thesis:
- successful completion of the bachelor programme;
- fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
The Master's thesis concludes the study program and demonstrates the students' ability to use the knowledge and skills acquired during Master's studies to solve a complex cyber security problem.

Objective
To work independently and to produce a scientifically structured work.

Cyber Security Master - Key for Type

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

Key for Hours

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

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-0649-01L</td>
<td>Applied Statistical Regression I</td>
<td>O</td>
<td>4 credits</td>
<td>1V+1U</td>
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<tr>
<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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<td></td>
<td>Objective</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>447-0649-02L</td>
<td>Applied Statistical Regression II</td>
<td>O</td>
<td>2 credits</td>
<td>1V+1U</td>
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</tr>
<tr>
<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Generalized linear models (GLMs) and basic ideas of more advanced regression models.</td>
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<tr>
<td>447-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design I</td>
<td>O</td>
<td>3 credits</td>
<td>1V+1U</td>
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<tr>
<td></td>
<td>Design I</td>
<td></td>
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<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<tr>
<td></td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Understanding the concept and flexibility of generalized linear models and correct interpretation of the corresponding model outputs.</td>
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<tr>
<td>447-6201-00L</td>
<td>Nonparametric and Resampling Methods</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
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<tr>
<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>For classical parametric models there exist optimal statistical estimators and test statistics whose distributions can often be determined exactly. The methods covered in this course allow for finding statistical procedures for more general models and to derive exact or approximate distributions of complicated estimators and test statistics.</td>
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<tr>
<td>447-0990-00L</td>
<td>Workshop</td>
<td>O</td>
<td>1 credit</td>
<td>1S</td>
<td>L. Meier</td>
</tr>
<tr>
<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>In the workshop each participant gives a short talk about a recent statistical problem encountered in their daily work.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Presentation of a statistical problem, getting to know different applications of statistical methodology.</td>
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</tbody>
</table>

### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-0625-02L</td>
<td>Applied Analysis of Variance and Experimental Design II</td>
<td>W</td>
<td>3 credits</td>
<td>1V+1U</td>
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</tr>
<tr>
<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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</tr>
<tr>
<td></td>
<td>Abstract</td>
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</tr>
<tr>
<td></td>
<td>Random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Participants will be able to plan and analyze sophisticated experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<tr>
<td>447-6221-00L</td>
<td>Nonparametric Regression</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>M. Mächler</td>
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<tr>
<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This course focuses on nonparametric estimation of probability densities and regression functions. These recent methods allow modelling without restrictive assumptions such as 'linear function'. These smoothing methods require a weight function and a smoothing parameter. Focus is on one dimension, higher dimensions and samples of curves are treated briefly. Exercises at the computer. Knowledge on estimation of probability densities and regression functions via various statistical methods. Understanding of the choice of weight function and of the smoothing parameter, also done automatically. Practical application on data sets at the computer.</td>
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<tr>
<td>447-6257-00L</td>
<td>Repeated Measures</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>L. Meier</td>
</tr>
<tr>
<td></td>
<td>Does not take this semester. Only for DAS and CAS in Applied Statistics.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Special Students &quot;University of Zurich (UZH)&quot; in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to <a href="mailto:registrar@ethz.ch">registrar@ethz.ch</a>. The Registrar's Office will then register you for the course.</td>
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</table>
### Sampling Surveys

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Semester</th>
<th>Taught by</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-6289-00L</td>
<td>2</td>
<td>W</td>
<td>B. Hulliger</td>
</tr>
</tbody>
</table>

**Objective**
Participants will gain the ability of recognizing repeated measures and to analyze them adequately. They will know how to deal with pseudoreplicates.

**Abstract**
The elements of a sample survey are explained. The most important classical sample designs (simple random sampling and stratified random sampling) with their estimation procedures and the use of auxiliary information including the Horvitz-Thompson estimator are introduced. Data preparation, non-response and its treatment, variance estimation and analysis of survey data is discussed.

**Lecture notes**
Introduction to the statistical methods of survey research

### Deep Learning: A Probabilistic Approach

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Semester</th>
<th>Taught by</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-6265-00L</td>
<td>2</td>
<td>W</td>
<td>O. Dürr, B. Sick</td>
</tr>
</tbody>
</table>

**Objective**
You will learn about different neural network architectures (e.g. fully connected and convolutional neural networks) and how to choose the appropriate NN architecture for your task at hand.

**Abstract**
This course introduces probabilistic deep learning (DL). DL is used for data with complex features like images. We treat DL as probabilistic models, as a continuation of GLMs (logistic regression, ...). The models are fitted with maximum likelihood or Bayesian learning.

**Lecture notes**
Slides, descriptions of the problems for the data analyses and worked-out solutions to them will be provided.

### Spatial Statistics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Semester</th>
<th>Taught by</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-6233-00L</td>
<td>1</td>
<td>W</td>
<td>B. Sick</td>
</tr>
</tbody>
</table>

**Objective**
The course will provide an overview of the basic concepts and stochastic models that are commonly used to model geostatistical data sets. In addition, the participants will learn a number of geostatistical techniques and acquire some familiarity with software that is useful for analysing spatial data.

**Content**
After an introductory discussion of the types of problems and the kind of data that arise in environmental research, an introduction into linear geostatistics (models: stationary random processes, modelling large-scale spatial patterns by regression, modelling autocorrelation by variogram; kriging: mean-square prediction of spatial data) will be taught. The lectures will be complemented by data analyses that the participants have to do themselves.

**Lecture notes**
Slides, descriptions of the problems for the data analyses and worked-out solutions to them will be provided.

**Literature**

### Applied Bayesian Statistics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Semester</th>
<th>Taught by</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-6273-00L</td>
<td>2</td>
<td>W</td>
<td>S. Robert</td>
</tr>
</tbody>
</table>

**Objective**
You will learn to model different outcome distributions such as Gaussians, Poissonians, or Multinomial for the task at hand.

**Abstract**
This course introduces probabilistic deep learning (DL). DL is used for data with complex features like images. We treat DL as probabilistic models, as a continuation of GLMs (logistic regression, ...). The models are fitted with maximum likelihood or Bayesian learning.

**Lecture notes**
Introduction to the statistical methods of survey research
Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

### Abstract

Introduction to Bayesian statistics: basics of inference, computation with MCMC, linear model, logistic regression, Bayesian hierarchical models. Focus on applications and hands-on programming.

### Objective

- understand the basics of Bayesian inference
- use R packages to run MCMC algorithms
- fit and understand Bayesian linear models
- introduction to hierarchical Bayesian models

### Content

We will learn how to describe business/scientific problems as probabilistic models, apply Bayes rules to draw inference from data, and use the probabilistic programming language STAN to obtain samples from posterior distributions. On the way we will fit linear models both for continuous and categorical outcomes, and explore techniques to deal with hierarchical structures in the data. There will be examples of applications from various fields: insurance, meteorology, marketing, etc.

### Literature

Bayes Rules! An Introduction to Applied Bayesian Modeling, Alicia A. Johnson, Miles Q. Ott, Mine Dogmucu - CRC Press 2022

### Prerequisites / notice

- introductory statistics
- applied regression
- R

### 447-6191-00L Statistical Analysis of Financial Data

**W** 2 credits 1G M. Dettling, A. F. Ruckstuhl

**Abstract**


### Objective

Getting to know the typical properties of financial data and appropriate statistical models, incl. the corresponding functions in R.

### 447-6255-00L Analysis of High-Dimensional Data

**W** 1 credit 1G N. Städler

**Abstract**

Block course on analysis of high-dimensional data with a focus on prediction and feature assessment.

**Objective**

The goal of this course is to gain a good understanding of the concepts discussed during the lecture and to apply the new methods on real data examples using the software "R". The topics covered in the lecture are:

Part 1: Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization

Part 2: Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

### Content

Course on Analysis of High-Dimensional Data with focus on Prediction and Feature Assessment.

**Part 1: Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization**

**Part 2: Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage**

### Lecture notes

The block course is based on lecture notes (https://bookdown.org/staedler_n/highdimstats/).

### Literature


### Prerequisites / notice

- The exercises are done exclusively with the (free, open source) software "R" (http://www.r-project.org). A final exam will also happen at the computers, using R (and your brains!).

### Taught competencies

- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

- Project Management

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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Diploma Thesis

<table>
<thead>
<tr>
<th>Number</th>
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<td>O</td>
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</table>

Abstract

The diploma thesis typically consists of a data analysis of data from a participant's own field of work. The thesis requires a time expenditure of about one or two weeks. Thesis work should prove the participants' capability to apply useful and modern statistical methods to address appropriate questions properly and effectively.

Objective

Thesis work should prove the participants' capability to apply useful and modern statistical methods to address appropriate questions properly and effectively.

DAS in Applied Statistics - Key for Type

<table>
<thead>
<tr>
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<table>
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Key for Hours

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</tr>
<tr>
<td>U</td>
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<table>
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<tr>
<td>■</td>
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</table>
DAS in Cyber Security

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>O</td>
<td>7 credits</td>
<td>2V+2U+2A</td>
<td>S. Caprun, S. Shinde</td>
</tr>
</tbody>
</table>

**Abstract**
The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.

**Objective**
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

**Content**
The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), large security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>263-4640-00L</td>
<td>Network Security</td>
<td>O</td>
<td>8 credits</td>
<td>2V+2U+3A</td>
<td>A. Perrig, S. Frei, M. Legner, K. Paterson</td>
</tr>
</tbody>
</table>

**Abstract**
Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

This course provides an in-depth study of network attack techniques and methods to defend against them.

**Objective**
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

**Content**
The course will cover topics spanning four broad themes with a focus on the first two themes:

1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

**Prerequisites / notice**
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

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

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>268-0101-00L</td>
<td>Introduction to Information Security</td>
<td>O</td>
<td>5 credits</td>
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<td>P. Schaller, S. Matetic</td>
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</table>

**Abstract**
In this course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students’ understanding of the theory parts.

**Objective**
Graduates of the course know the technical foundations of information security and understand the difficulty and complexity involved when trying to build secure systems.

**Content**
In this new course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students’ understanding of the theory parts.

<table>
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<tr>
<td>268-0102-00L</td>
<td>Applied Security Laboratory</td>
<td>O</td>
<td>5 credits</td>
<td>3P</td>
<td>D. Basin</td>
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**Abstract**
Only for DAS in Cyber Security.
Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, logging), application security with an emphasis on web applications (web server setup, common web exploits, authentication, session handling, code security), computer forensics, and risk analysis and risk management.

This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectiveness and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.


Recommended reading includes:
* Various: OWASP Guide to Building Secure Web Applications, available online
* O'Reilly, Loukides: Unix Power Tools, O'Reilly & Associates.
* Frisch: Essential System Administration, O'Reilly & Associates.
* NIST: Risk Management Guide for Information Technology Systems, available online as PDF
* BSI: IT-Grundschutzhandbuch, available online

The lab allows flexible working since there are only few mandatory meetings during the semester. The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas: information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.

Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the recommended requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.

All participants must sign the lab's charter and usage policy during the introduction lecture.

Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include
* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security
Objective

After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.

Content


<table>
<thead>
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<th>Course Code</th>
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<th>Credits</th>
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<td>268-0202-00L</td>
<td>Contemporary Topics in Cyber Security</td>
<td>3</td>
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</table>

Abstract

Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.

Objective

Participants have understood and presented a publication or report on a present topic in information security. By attending other participants presentations students get further introduced to additional current information security related topics/incidents.

Content

Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.

Abstract

This course is composed of various sub-modules related to Cyber Security taught by experts on the relevant fields.

Objective

Students are expected to see behind the curtain of current research and engineering activities related to Cyber Security. At the same time students are introduced to contemporary challenges in cyber security by renowned experts.

Content

The lectures cover contemporary aspects and challenges in Cyber Security. The goal is to present current fields of research/engineering and the latest results. By way of example, Cyber Security Policy is one of sub-modules presented by researchers of the Center for Security Studies at ETH. Besides faculty members of the computer science department, there will be guest lecturers from industry presenting Cyber Security related challenges in their field of activity.

Literature

Will be announced during the course.

DAS in Cyber Security - Key for Type

<table>
<thead>
<tr>
<th>Type Code</th>
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Key for Hours

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<td>P</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
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<tr>
<td>R</td>
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ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# DAS in Data Science

## Core Courses

### Foundations Courses

<table>
<thead>
<tr>
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<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

**Abstract**
Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

**Objective**
Students master the basic mathematical concepts and algorithms of estimation and machine learning.

**Content**
- Review of probability theory;
- basics of statistical estimation;
- least squares and linear learning;
- Hilbert spaces;
- singular-value decomposition;
- kernel methods, neural networks, and more

**Lecture notes**
Lecture notes will be handed out as the course progresses.

### Capstone Project

<table>
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<th>Hours</th>
<th>Lecturers</th>
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</table>

**Abstract**
The capstone project is part of the DAS in Data Science and is an opportunity to apply the knowledge acquired in the program in an independent, real-world project.

**Objective**
To apply the knowledge acquired in the program in an independent, real-world project.

**Content**
The capstone project can be done under the supervision of the Swiss Data Science Center, or of any core or adjunct faculty of Data Science. The project has to be finished within 6 months. Deadline for a project the following semester conducted at the SDSC is mid June/mid December.

## Specialisation Track

### Hardware for Machine Learning

*Offered in the Spring Semester.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>227-0155-00L</td>
<td>Machine Learning on Microcontrollers</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>M. Magno, L. Benini</td>
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</table>

**Abstract**
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly “smart”. This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the “internet-of-things”, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

**Objective**
Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

**Content**
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

**Lecture notes**
Script and exercise sheets. Books will be suggested during the course.

**Prerequisites / notice**
Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

## Image Analysis & Computer Vision

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>W</td>
<td>8</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
</tr>
</tbody>
</table>

**Abstract**
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.
Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To equip participants to make sense of the computer vision literature.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition.

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

Neural Information Processing

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0421-00L</td>
<td>Deep Learning in Artificial and Biological Neuronal Networks</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Grewé</td>
</tr>
</tbody>
</table>

Abstract
Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neurophysiology of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data that they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes
The lecture slides will be provided as a PDF after each lecture.

Prerequisites
This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariable calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

Neuromorphic Engineering I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu</td>
</tr>
</tbody>
</table>

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites / notice
Background in basics of semiconductor physics helpful, but not required.
### Statistics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

**Abstract**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Objective**
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

| 401-0649-00L | Applied Statistical Regression                     | W    | 5 credits | 2V+1U | M. Dettling |

**Abstract**
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poison regression for count data.

**Literature**

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

**Taught competencies**

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

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

<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Communication</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

**Personal Competencies**

<table>
<thead>
<tr>
<th>Adaptability and Flexibility</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

| 401-3612-00L | Stochastic Simulation                  | W    | 5 credits | 2V+1U | F. Sigrist |

**Abstract**
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

**Objective**
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

**Content**

**Lecture notes**
A script will be available in English.
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis.

The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Processes, Non-stationary Processes, Spectral Analysis, and Forecasting.

**Objective**

- Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

**Contents**

- In the Regression course, we will consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models.
- Several numerical examples will illustrate the theory.
- In the Theory and Techniques of Stationary Processes course, we will cover the main concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3620-00L</td>
<td>Time Series Analysis</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Meinshausen</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.</td>
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<tr>
<td>Content</td>
<td>This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>The main reference for this course is the book &quot;Introduction to Time Series and Forecasting&quot;, by P. J. Brockwell and R. A. Davis.</td>
<td></td>
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</tbody>
</table>

**Prerequisites / notice**

Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

**Machine Learning and Artificial Intelligence**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0689-00L</td>
<td>System Identification</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>R. Smith</td>
</tr>
<tr>
<td>Abstract</td>
<td>Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.</td>
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<td></td>
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</tbody>
</table>

**Additional references**

- Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)
- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)
252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-3005-00L Natural Language Processing W 7 credits 3V+3U+1A R. Cotterell

Abstract
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

263-2400-00L Reliable and Trustworthy Artificial Intelligence W 6 credits 2V+2U+1A M. Vechev

Abstract
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.
The course is split into 3 parts:

Robustness in Deep Learning

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Taught competencies

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

Method-specific Competencies

| Analytical Competencies | assessed |
| Problem-solving | assessed |

Personal Competencies

| Creative Thinking | assessed |
| Critical Thinking | assessed |

Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

263-3210-00L Deep Learning

Number of participants limited to 320.

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

263-5210-00L Probabilistic Artificial Intelligence

W 8 credits 3V+2U+2A A. Krause

Abstract

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.
Big Data Systems

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

Content

- Lecture material (slides).

Prerequisites / notice
For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

----------------------------------
Number Title Type ECTS Hours Lecturers
252-0834-00L Information Systems for Engineers W 4 credits 2V+1U G. Fourny

Abstract
This course provides the basics of relational databases from the perspective of the user.

Objective
This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature


Prerequisites / notice

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 572 of 2345
Number of participants limited to 125.

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3010-00L
Big Data W 10 credits 3V+2U+4A G. Fourny

Abstract
The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Objective
This combination of requirements, together with the technologies that have emerged in order to address them, is typically referred to as "Big Data." This revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.

Content
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?*, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Literature
Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Prerequisites / notice
This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
### DAS in Data Science - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
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<tr>
<td>W+</td>
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<td>Z</td>
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<tr>
<td>Dr</td>
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### Key for Hours

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

ECTS  
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Subjects of Specialization

Subjects are to be chosen from the courses offered in the master degree program in electrical engineering and information technology. The director of studies decides on exceptions, upon consultation with the tutor.

Course offer from the Master Program in Electrical Engineering and Information Technology

Diploma Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, “in this paper” paragraph, scientific part, summary, equations, figures)
* Topic 2: Structure of Scientific Presentations
* Topic 3: Citation Rules and Citation Software
* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
ETH “Citation Etiquette”, see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html
ETH “Scientific Integrity”, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-3001-00L</td>
<td>Diploma Thesis</td>
<td>O</td>
<td>12</td>
<td>36D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Registration for the diploma thesis requires the successful completion of 18 credits ECTS from subjects of specialization.

Abstract
The Diploma of Advanced Studies finishes with a 3-months diploma thesis which is directed by a professor of the department ITET. Students prove their ability to conduct independent scientific research on a specific research problem, using skills and knowledge acquired during the program. The thesis includes a written report and an oral presentation.

Key for Type

<table>
<thead>
<tr>
<th>Key</th>
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<tbody>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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</table>

Key for Hours

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<th>Type</th>
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<tr>
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<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**DAS in Military Sciences**

The DAS in Military Sciences programme is executed every second year, next start: Autumn Semester 2023.

### DAS in Military Sciences - Key for Type

<table>
<thead>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>Courses outside the curriculum</td>
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### Key for Hours

<table>
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<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
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<td>A</td>
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<td>revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### DAS in Spatial Planning

#### Lectures

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>115-0510-00L</td>
<td>Lecture Week 10: Spatial Development</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>M. Nollert, J. Van Wezemael</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>In this course, the fundamental methods in spatial planning learned in the first week, in particular regarding planning methodology, spatial design and argumentation are consolidated in lectures and case studies.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The aim of the lecture is the consolidation and the practice of important methodic principles in spatial planning. They provide a basis also for the work in the second Study Project of the MAS program.</td>
<td></td>
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</tr>
<tr>
<td>115-0511-00L</td>
<td>Lecture Week 11: Urban Planning and Urban Design II</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>S. Kretz, to be announced</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The second week on urban design and urban planning focuses on a case study in the field of strategic urban design. The course includes lectures, discussions, methodological inputs and a design workshop. Students analyze and discuss a real life problem and elaborate proposals for a suitable urban design strategy.</td>
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<tr>
<td>Objective</td>
<td>The aim of the course is an in-depth understanding of contemporary urban design challenges and an exemplary, case-based experience of elaborating adequate urban design strategies.</td>
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<tr>
<td>115-0512-00L</td>
<td>Lecture Week 12: Spatial Planning: Theory and Methodology</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>A. Voigt</td>
</tr>
<tr>
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<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>Impart thinking patterns and active application of fundaments of planning theories and methods. The main focus is on plausibility and rigor of reasoning in spatial planning, from problem definition and analysis of its causes to the formulation of robust solutions; development of different planning steps considering communication theory and ethical aspects.</td>
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<tr>
<td>Objective</td>
<td>Autonomous and productive application of analyzed thinking patterns and planning steps; situationally appropriate and task-oriented transfer to new planning problems.</td>
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<tr>
<td>115-0513-00L</td>
<td>Lecture Week 13: Academic Working in Spatial Planning</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>R. Nebel, A. Rupf</td>
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<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>Understanding what scientific work means in spatial planning. Procedures for clarification processes; basics of scientific working and writing; case studies and exercises.</td>
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<tr>
<td>Objective</td>
<td>Knowledge for a scientific way of working; structuring a scientific paper using the example of the DAS Synopsis or MAS Thesis.</td>
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<tr>
<td>115-0514-00L</td>
<td>Lecture Week 14: Spatial Planning: International Aspects</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>F. Persyn</td>
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<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>Introduction to international perspectives in spatial planning. Exploring various scales and their interconnectedness as well as flows and practices that bridge different cultures of planning. International competitions as a tool to navigate different planning realities, terrains and transformations.Team work on an ongoing case.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Learning from different spatial planning cultures, their interaction and improving the capacity to understand and bring solutions to diverse planning contexts.</td>
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</table>

### DAS in Spatial Planning - Key for Type

<table>
<thead>
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<th>W+</th>
<th>Z</th>
<th>Dr</th>
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<tbody>
<tr>
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<td>Eligible for credits and recommended</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
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<tr>
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### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### DAS Preparation for the Swiss Federal Examination in Pharmacy

#### First Series of Courses (Group A)

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.</td>
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<tr>
<td><strong>Content</strong></td>
<td>I) Genomics and transcriptomics</td>
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<td></td>
<td>Methods and Techniques:</td>
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<tr>
<td></td>
<td>• Recombinant DNA technology</td>
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<td></td>
<td>• Next generation sequencing methods, sequencing of genomes</td>
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<td></td>
<td>• CRISPR technology</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Application to human biology:</td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>• Functional genomics/transcriptomics</td>
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<tr>
<td><strong>Content</strong></td>
<td>• Principles of cancer, genetic diseases</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>• Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination</td>
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<tr>
<td><strong>Objective</strong></td>
<td>II) Proteomics</td>
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<tr>
<td><strong>Content</strong></td>
<td>Methods and Techniques:</td>
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<td></td>
<td>• Protein cloning and expression</td>
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<td></td>
<td>• The antibody molecule</td>
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<td></td>
<td>• Measurement and determination of biomolecular interactions</td>
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<td></td>
<td>• Protein characterization and engineering</td>
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<td></td>
<td>• Modifications and radioactive labelling</td>
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</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Application to human biology:</td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>• Protein therapeutics</td>
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<tr>
<td><strong>Content</strong></td>
<td>• Proteomic approaches for identification of novel disease-related targets and biomarkers</td>
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</table>

| **Abstract**   | The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples. |
| **Objective**  | Lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields. |
| **Content**    | III) Drug discovery: Protein-based libraries |
|                | • Immune repertoire mining         |
|                | • Display and selection technologies |
|                | 1. antibody phage display          |
|                | 2. other polypeptide display technoloies |
|                | 3. small-molecules display: DNA-encoded chemical libraries |

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>535-0830-00L</td>
<td>Pharmaceutical Immunology</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>C. Halin Winter, V. Collado Diaz</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Get Students familiar with basic Immunological concepts of pharmaceutical relevance.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Get Students familiar with basic Immunological concepts of pharmaceutical relevance.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Chapters 1 - 11 of the Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition; Garland). Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition).</td>
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<td>Paperback [<a href="http://www.garlandscience.com">www.garlandscience.com</a>]</td>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>535-0421-00L</td>
<td>Galenical Pharmacy I</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>J.-C. Leroux, E. Giger</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharm. excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality and application. Comprehension of molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Knowledge of the most important pharmaceutical excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality, stability and application. Comprehension of the molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in disperse dosage forms.</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>Introduction and overview of important fundamentals, principles and technologies for the development and manufacturing of dosage forms and drug delivery systems. Overview of the most important pharmaceutical excipients and polymers, their structure, properties and processing; importance of materials properties for containers. Pharmaceutical solvents, fundamentals of solubility and solubilization of drugs. Water treatment processes, sterilization techniques and quality requirements of pharmaceutical water. Parenteral dosage forms and liquid ophthalmics. Surfactants, micelle formation and colloidal systems. Liquid suspensions and emulsions. Stabilization measures in dosage forms.</td>
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</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Literature</td>
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<tr>
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<td>Literature</td>
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</table>

**Prerequisites / notice**

Language: German and English

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 578 of 2345
Abstract
The course places the basic pharmaceutical knowledge acquired so far in an applied therapeutic context and fosters interdisciplinary thinking in pharmaceutical sciences. Common pharmaceutical case studies, as they can occur in the professional everyday life of a pharmacist, are worked out in group works, presented and discussed.

Objective
Students
• Are able to analyse, present and discuss common case studies from the pharmacist's practice, based on their basic knowledge in pharmacology.
• deepen their knowledge of therapeutic substance classes and therapy guidelines.
• are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to undesirable other effects and interactions).
• are able to compare different drugs and derive their therapy-relevant characteristics.

Content
Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:
• Indication
• Dosage Form
• Adverse Drug Reactions
• Interactions
• Contraindications

Lecture notes
Is made available via Moodle.

Literature
As stated in the cases.

Prerequisites / notice
The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and discussed in plenary.
Literature

Recommended reading:

Klaus Aktories, Ulrich Förstermann, Franz Hofmann, Klaus Starke. 
Allgemeine und spezielle Pharmakologie und Toxikologie. 
Urban & Fischer (Elsevier, München) 

The classic textbook in Pharmacology:

Goodman and Gilman’s The Pharmacological Basis of Therapeutics 
Laurence Brunton, Bjorn Knollman, Randa Hilal-Dandan. 
ISBN-10: 1259584739 

or 14th Edition (expected Dec. 2022)

Prerequisites / notice

Voraussetzungen: Abschluss Grundstudium

Second Series of Courses (Group A)

Compulsary Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

Objective

Students

- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

Content

"Pharmaceutical Care" und "Health Care":
- Häufigste Erkrankungen und Therapien der
  - Allergologie
  - Angiologie und Hämatologie
  - Dermatologie
  - Endokrinologie und Diabetologie
  - Gastroenterologie
  - Infektiologie
  - Kardiologie
  - Neurologie
  - Ophthalmologie
  - Otorhinolaryngologie
  - Pneumologie
  - Psychiatrie
  - Rheumatologie
  - Urologie
- Grundlagen der Chiropraktischen Medizin und Physiotherapie.

Lecture notes

Provided via myStudies.

Literature

As stated in the lecture notes.

Prerequisites / notice

The performance assessments take place on: 20.12.2022 (approx. 11-13h) und 21.12.2022 (approx. 14-16h)

Please note that the assessment of this course must be passed (not compensable).

The performance assessment of the course takes place in two written on campus online partial examinations. The overall grade results from the average of the grades of both partial examinations. If the overall grade is unsatisfactory, both partial examinations must be repeated.

The courses Pharmacology and Toxicology I and II and Pathobiology provide indispensable basics which students must master at the beginning of the semester in order to successfully complete the course.

Pharmacology and Toxicology III must be visited at the same time.

Compulsary Courses II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0030-00L</td>
<td>Therapeutic Proteins</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>C. Halin Winter, D. Neri</td>
</tr>
</tbody>
</table>

Abstract

In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

Objective

Students know and understand:

- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins
The course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through:

- Historical landmarks of drug safety
- Pharmacology and toxicogenomics, the course is focused on genetics, genome-wide association studies, examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development.

**Objectives:**
The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases and cancer. The course also provides an overview of the field of pharmacogenomics and toxicogenomics, with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

**Content:**
Topics include the pharmacology and pharmacotherapy of infectious diseases and cancer. In the field of pharmacogenomics and toxicogenomics, the course is focused on genetics, genome-wide association studies, examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development.

**Literature:**
Recommended reading:
- The classic textbook in Pharmacology: Goodman and Gilman’s The Pharmacological Basis of Therapeutics
- or 14th edition (expected Oct. 2022)

**535-0050-00L** Pharmacopoeidemiology and Drug Safety

**Objective:**
Objectives:
- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for the quantitative evaluation of drug safety
- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

**Content:**
- Historical landmarks of drug safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)
- Medication errors, clinical pharmacology / clinical pharmacy
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, ‘Big Data’
- Interactive discussion of many real-life examples for each topic

**Literature:**
Recommended literature:
- Rothman: Introduction to Epidemiology
- Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
- Gigerenzer: Risk Savvy - How to Make Good Decisions

**535-0137-00L** Clinical Chemistry II

**Objective:**
Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Content:**
Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Lecture notes:**
Documentation will be available before the lectures electronically.
Second Series of Courses (Group B)

### 535-5512-00L Triage, Diagnostics, Therapy Support

**Type:** O  
**ECTS:** 9 credits  
**Hours:** 12G  
**Lecturers:** E. Kut Bacs, S. Eni, P. Obrist, D. Petralli-Nietlispach, S. Ruppen, I. S. Vogel Kahmann, P. Wiedemeier

**Abstract:** This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

**Objective:**
- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

**Content:**
- "Pharmaceutical Care" und "Health Care";
- Häufigste Erkrankungen und Therapien der
  - Allergologie
  - Angiologie und Hämatologie
  - Endokrinologie und Diabetologie
  - Gastroenterologie
  - Infektiologie
  - Kardiologie
  - Neurologie
  - Ophthalmologie
  - Otorhinolaryngologie
  - Pneumologie
  - Psychiatrie
  - Rheumatologie
  - Urologie
- Grundlagen der Chiropunktiven Medizin und Physiotherapie.

**Lecture notes:** Provided via myStudies.

**Literature:** As stated in the lecture notes.

**Prerequisites / notice**
- The performance assessments take place on: 20.12.2022 (approx. 11-13h) and 21.12.2022 (approx. 14-16h)

Please note that the assessment of this course must be passed (not compensable).

The performance assessment of the course takes place in two written on campus online partial examinations. The overall grade results from the average of the grades of both partial examinations. If the overall grade is unsatisfactory, both partial examinations must be repeated.

The courses Pharmacology and Toxicology I and II and Pathobiology provide indispensable basics which students must master at the beginning of the semester in order to successfully complete the course.

Pharmacology and Toxicology III must be visited at the same time.

### 535-0137-00L Clinical Chemistry II

**Type:** O  
**ECTS:** 1 credit  
**Hours:** 1V  
**Lecturer:** M. Hersberger

**Abstract:** Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Objective:** Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interpret selected tests.

**Content:** Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Lecture notes:** Documentation will be available before the lectures electronically.

**Literature:**
- Jürgen Hallbach, Klinische Chemie und Hämatologie für den Einstieg, Thieme Verlag
- Harald Renz, Praktische Labordiagnostik, de Gruyter Verlag
- Walter Guder, Das Laborbuch für Klinik und Praxis , Elsevier Verlag
- Lothar Thomas, Labor und Diagnose , TH Books
- William Marshall, Clinical Chemistry , Mosby Ltd.
- Alan H.B. Wu, Tietz, Clinical Guide to Laboratory Tests , Saunders

**Prerequisites / notice**
- Requirement: basic knowledge in clinical chemistry and laboratory diagnostics

Third Series of Courses (Group A and B)

#### Practical Pharmacy I and Compensatory Courses

### 535-5521-00L Therapeutic Skills I

**Type:** O  
**ECTS:** 3 credits  
**Hours:** 3G  
**Lecturers:** A. Küng Krähenmann, S. Eni, E. Kut Bacs, D. Petralli-Nietlispach, D. Stämpfl, I. S. Vogel Kahmann, P. Wiedemeier

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This course provides basic knowledge relevant to pharmacy and its application in nephrology, phytotherapy, complementary medicine, wound care and pharmaceutical care.

### Content
- complementary medicine
- phytotherapy
- wound care
- pharmaceutical care 2
- pharmacy

### Lecture notes
Provided via myStudies.

### Literature
As specified in the lecture notes

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-5502-00L</td>
<td>Pharmaceutical Manufacturing in Small Quantities (Compounding)</td>
<td>O</td>
<td>3</td>
<td>5G</td>
<td>P. G. Tiefenböck, A. Romagna</td>
</tr>
<tr>
<td>535-5503-00L</td>
<td>Institutional Pharmacy</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>P. Wiedemeier, M. Lutters, E. Martinelli, I. S. Vogel Kahmann</td>
</tr>
</tbody>
</table>

### Objective
Students know and understand the therapeutic concepts of the mentioned topics and their application in practice.

### Content
(for detailed learning objectives see the guidelines)

### Lecture notes
Provided via myStudies.

### Literature
As specified in the lecture notes

### Practical Pharmacy II

### Number | Title                                | Type | ECTS | Hours | Lecturers                                      |
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>535-5524-00L</td>
<td>Clinical Trainings</td>
<td>O</td>
<td>2</td>
<td>3G</td>
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<tr>
<td>535-5502-00L</td>
<td>Pharmaceutical Manufacturing in Small Quantities (Compounding)</td>
<td>O</td>
<td>3</td>
<td>5G</td>
<td></td>
</tr>
<tr>
<td>535-5503-00L</td>
<td>Institutional Pharmacy</td>
<td>O</td>
<td>2</td>
<td>3G</td>
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</tr>
</tbody>
</table>
Principals of the organisation of institutional environments (emergency hospitals), with special focus on medication processes and institutional pharmaceutical care (circulation of medication, continuum of care). Hygiene regulations, medical products, applications, drug formularies, patient files, SOAP notes, kardex study. Participation at interdisciplinary visits, internal trainings and doctors' reports as well as visitation of the emergency room. Drug interaction, generic substitution, quality management and pharmacovigilance.

**535-5526-00L** Injection Techniques and Vaccinations

**Abstract**
Die Studierenden erlernen die praktische Durchführung von subkutanen (s.c.) und intramuskulären (i.m.) Injektionen. Sie wissen, wie in Notfallsituationen vorzugehen ist. Die Besonderheiten von häufig eingesetzten parenteral zu verabreichenden Medikamenten, insbesondere von Impfungen, sind bekannt.

**Objective**
Die Studierenden werden im praktischen Teil geübt, in Notfallsituationen vorzugehen. Sie lernen die besonderen Aspekte bei der Durchführung von Impfungen zu kennen.

**Content**

**Lecture notes**
Wird auf mystudies veröffentlicht.

**Literature**
Wird im Skript angegeben.

**Prerequisites / notice**

Schutzkonzept: https://chab.ethz.ch/studium/bachelor1.html

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**DAS Preparation for the Swiss Federal Examination in Pharmacy - Key for Type**

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

**Key for Hours**

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

**ECTS**
European Credit Transfer and Accumulation System

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

#### Core Courses

#### Data Analysis

#### Information and Learning

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


**Prerequisites / notice**

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0423-00L</td>
<td>Neural Network Theory</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Bölcskei</td>
</tr>
</tbody>
</table>

**Abstract**

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

**Objective**

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

**Lecture notes**

Detailed lecture notes are available on the course web page [https://www.mins.ee.ethz.ch/teaching/int/](https://www.mins.ee.ethz.ch/teaching/int/)

**Prerequisites / notice**

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

#### Statistics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3621-00L</td>
<td>Fundamentals of Mathematical Statistics</td>
<td>W</td>
<td>10</td>
<td>4V+1U</td>
<td>S. van de Geer</td>
</tr>
</tbody>
</table>
The course covers the basics of inferential statistics.

### Data Management

#### Randomized Algorithms and Probabilistic Methods

**Number**: 252-0417-00L  
**Title**: Randomized Algorithms and Probabilistic Methods  
**Type**: W  
**ECTS**: 10 credits  
**Hours**: 3V+2U+4A  
**Lecturers**: A. Steger

**Abstract**
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

**Objective**
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**
Randomized Algorithms are algorithms that “flip coins” to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Lecture notes**
Yes.

**Literature**

#### Big Data

**Number**: 263-3010-00L  
**Title**: Big Data  
**Type**: W  
**ECTS**: 10 credits  
**Hours**: 3V+2U+4A  
**Lecturers**: G. Fourny

**Abstract**
The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

**Objective**
This combination of requirements, together with the technologies that have emerged in order to address them, is typically referred to as “Big Data.” This revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science — which is sometimes referred to as data-driven science or the “fourth paradigm”.

Unfortunately, the quantity of data produced and available — now in the Zettabyte range (that’s 21 zeros) per year — keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today’s technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.

**Content**
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

**Literature**
Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.
1. Discrete-time linear systems and filters: System Identification

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with System Identification for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

2V+1U

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed.

6 credits

4G

Discrete-Time and Statistical Signal Processing

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Type

Lecturers

4G

3V+1U+3A

A. Lapidoth

2V+1U

The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner.

The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

Prerequisites / notice

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

Taught competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Core Electives

Number Title Type ECTS Hours Lecturers

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea

Abstract

Introduction to Dynamic Programming and Optimal Control.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature


Prerequisites / notice

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

227-0101-00L Discrete-Time and Statistical Signal Processing W 6 credits 4G H.-A. Loeliger

Abstract

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content

1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum,
   - decimation and interpolation, digital filter design,
   - stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   - probability, random variables, discrete-time stochastic processes;
   - detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

Lecture Notes

227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity.

Content

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

227-0689-00L System Identification W 4 credits 2V+1U R. Smith

Abstract

Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.
Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.


Additional papers will be available via the course Moodle.

Prerequisites / notice
Closed-loop identification strategies. Trade-off between controller performance and information available for identification.

227-2210-00L
Computer Architecture

8 credits
W
6G+1A
O. Mutlu

Abstract
Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective
We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g., graph analytics, bioinformatics, machine learning, etc). We will focus on fundamentals as well as cutting-edge research.

Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

Lecture notes
See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

Literature
See https://safari.ethz.ch/architecture for past examples.

We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.


252-1414-00L
System Security

7 credits
W
2V+2U+2A
S. Capkun, S. Shinde

Abstract
The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers individual system’s aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

252-3005-00L
Natural Language Processing

7 credits
W
3V+3U+1A
R. Cotterell

Abstract
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

261-5130-00L
Research in Data Science

6 credits
W
13A
Professors

Abstract
Independent work under the supervision of a core or adjunct faculty of data science.

Objective
Independent work under the supervision of a core or adjunct faculty of data science.

Content
Project done under supervision of an approved professor.
Prerequisites / notice
Only students who have passed at least one core course in Data Management and Processing, and one core course in Data Analysis can start with a research project.

A project description must be submitted at the start of the project to the studies administration.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Name</th>
<th>Type</th>
<th>Credits</th>
<th>V+U+A</th>
<th>Taught Competencies</th>
<th>Taught / notice</th>
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<tbody>
<tr>
<td>263-0006-00L</td>
<td>Algorithms Lab</td>
<td>W</td>
<td>8</td>
<td>4P+3A</td>
<td>A. Steger, E. Welzl</td>
<td>Only for master students!</td>
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<td></td>
<td>Abstract</td>
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<td>Students learn how to solve algorithmic problems given by a textual description (understanding problem setting, choosing appropriate modeling, suitable algorithms, and implementing them). Knowledge of basic algorithms and data structures is assumed; more advanced material and usage of standard libraries for combinatorial algorithms are introduced in tutorials.</td>
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<td>The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, CGAL, and BGL).</td>
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<td>263-0009-00L</td>
<td>Information Security Lab</td>
<td>W</td>
<td>8</td>
<td>2V+1U+3P+1A</td>
<td>K. Paterson, D. Basin, S. Capkun, D. Hofheinz, A. Perrig, S. Shinde</td>
<td>Only for master students!</td>
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<td>Abstract</td>
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<td>This InterFocus Course will provide a broad, hands-on introduction to Information Security, introducing adversarial thinking and security by design as key approaches to building secure systems.</td>
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<td>This course will introduce key concepts from Information Security, both from attack and defence perspectives. Students will gain an appreciation of the complexity and challenge of building secure systems.</td>
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<td>The course is organised in two-week segments. In each segment, a new concept from Information Security will be introduced. The overall scope will be broad, including cryptography, protocol design, network security, system security.</td>
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<td>Lecture notes</td>
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<td>Will be made available during the semester.</td>
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<td></td>
<td>Paul C. van Oorschot, Computer Security and the Internet: Tools and Jewels.</td>
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<td>Dan Boneh and Victor Shoup, A Graduate Course in Applied Cryptography.</td>
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<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
<td>Only for master students!</td>
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<td>Abstract</td>
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<td>Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.</td>
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<td>Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.</td>
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<td>The course is split into 3 parts:</td>
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<td>- Robustness in Deep Learning</td>
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<td>- Adversarial attacks and defenses on deep learning models.</td>
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<td>- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).</td>
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<td>- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).</td>
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<td>Privacy of Machine Learning</td>
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<td>- Threat models (e.g., stealing data, poisoning, membership inference, etc.).</td>
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<td>- Attacking federated machine learning (across modalities such as vision, natural language and tabular).</td>
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<td>- Differential privacy for defending machine learning.</td>
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<td>- Enforcing regulations with guarantees (e.g., via provable data minimization).</td>
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<td>Fairness of Machine Learning</td>
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<td>- Introduction to fairness (motivation, definitions).</td>
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<td>- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).</td>
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<td>- Enforcing group fairness with guarantees.</td>
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<td>Prerequisites / notice</td>
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<td>While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in &quot;Intro to ML&quot; classes at most institutions (e.g., &quot;Introduction to Machine Learning&quot; at ETH).</td>
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<td>Taught competencies</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>W</td>
<td>9</td>
<td>3V+2U+3A</td>
<td>T. Hoefler, M. Püschel</td>
<td>Number of participants limited to 125.</td>
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<td></td>
<td>Abstract</td>
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<td>Advanced topics in parallel and high-performance computing.</td>
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<td>Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 589 of 2345
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture notes
Lecture slides will be made available at the course Web site.

Literature
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

Prerequisites / notice
There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

263-3210-00L Foundations of Reinforcement Learning W 5 credits 3V+2U+2A N. He

Abstract
Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control.

Prerequisites / notice
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Number of participants limited to 190.

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz, N. Perraudin

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is to gain a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

263-3005-00L Artificial Intelligence in Education W 3 credits 2V+1U M. Sachan, T. Sinha

Abstract
Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

Objective
The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

Content
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture notes
Lecture slides will be made available at the course Web site.

Literature
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

Prerequisites / notice
There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PHD students in other departments.

263-5210-00L Probabilistic Artificial Intelligence W 8 credits 3V+2U+2A A. Krause

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

263-5255-00L Does not take place this semester.

Number of participants limited to 190.

The course will be offered again in FS23.
Objective

This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to
- identify the strengths and limitations of various reinforcement learning algorithms;
- formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content

Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes

Lecture notes will be posted on Moodle.

Literature

Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepesvári.

Prerequisites / notice

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5300-00L Guarantees for Machine Learning

W 7 credits 3V+1U+2A  F. Yang, A. Sanyal
Number of participants limited to 30.

Abstract

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective

By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Teaching competencies

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH).

Taught competencies

Subject-specific Competencies
Concepts and Theories
assessed

Method-specific Competencies
Analytical Competencies
assessed
Problem-solving
assessed

Social Competencies
Communication
assessed
Cooperation and Teamwork
assessed

Personal Competencies
Creative Thinking
assessed
Critical Thinking
assessed

263-5902-00L Computer Vision

W 8 credits 3V+1U+3A  M. Pollefeys, S. Tang, F. Yu

Abstract

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve these.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

401-0625-01L Applied Analysis of Variance and Experimental Design

W 5 credits 2V+1U  L. Meier
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are covered:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorial designs and fractional designs, power.

Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorial designs and fractional designs, power.


- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

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A script will be available in English.

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields.

Examples of simulations in different fields (computer science, statistics, statistical mechanics, operations research, financial mathematics).

P. L. Bühlmann

11 credits

In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression.

8 credits

Stochastic Simulation

W

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.


Solid background in linear algebra.

Former course title: Mathematical Optimization.
Taught competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
Method-specific Competencies | Analytical Competencies | Decision-making | assessed
| Media and Digital Technologies | Problem-solving | assessed
| Project Management | not assessed
Social Competencies | Communication | assessed
| Cooperation and Teamwork | not assessed
| Customer Orientation | not assessed
| Leadership and Responsibility | not assessed
| Self-presentation and Social Influence | not assessed
| Sensitivity to Diversity | not assessed
| Negotiation | not assessed
Personal Competencies | Adaptability and Flexibility | not assessed
| Creative Thinking | assessed
| Critical Thinking | not assessed
| Integrity and Work Ethics | not assessed
| Self-awareness and Self-reflection | not assessed
| Self-direction and Self-management | not assessed

| 401-4623-00L | Time Series Analysis | W | 4 credits | 2G | N. Meinshausen
---|---|---|---|---|---
Abstract | The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.
Objective | The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.
Content | This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.
The key topics which will be covered as:
Stationarity
Autocorrelation
Trend estimation
Elimination of seasonality
Spectral analysis, spectral densities
Forecasting
ARMA, ARIMA, Introduction into GARCH models
Literature | The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis
Prerequisites / notice | Basic knowledge in probability and statistics

| 401-4944-20L | Mathematics of Data Science | W | 8 credits | 4G | A. Bandeira
---|---|---|---|---|---
Abstract | Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.
Objective | Introduction to various mathematical aspects of Data Science.
Content | These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.
Prerequisites / notice | The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.
We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary. A. Bandeira and H. Bölcskei

| 402-0461-00L | Quantum Information Theory | W | 8 credits | 3V+1U | J. Renes
---|---|---|---|---|---
Abstract | The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.
Objective | By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.
Content | Mathematical formulation of quantum theory; entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.
Lecture notes | Distributed via moodle.
Literature | Nielsen and Chuang, Quantum Information and Computation
Preskill, Lecture Notes on Quantum Computation
Wilde, Quantum Information Theory
Watrous, The Theory of Quantum Information

► Interdisciplinary Electives
This interactive course will explore the latest research on algorithms and data structures for population scale genomics applications and

Abstract

The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective

After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes

Scripts of all lectures will be available.

Literature


Taught competencies

Subject-specific Competencies

Concepts and Theories: assessed

Techniques and Technologies: assessed

Method-specific Competencies

Analytical Competencies: not assessed

Decision-making: assessed

Media and Digital Technologies: not assessed

Problem-solving: assessed

Project Management: not assessed

Social Competencies

Communication: not assessed

Cooperation and Teamwork: assessed

Customer Orientation: not assessed

Leadership and Responsibility: not assessed

Self-presentation and Social Influence: not assessed

Sensitivity to Diversity: not assessed

Negotiation: not assessed

Personal Competencies

Adaptability and Flexibility: assessed

Creative Thinking: assessed

Critical Thinking: assessed

Integrity and Work Ethics: not assessed

Self-awareness and Self-reflection: not assessed

Self-direction and Self-management: not assessed

Number of participants limited to 30.

Abstract

Research in Biology and Medicine have been transformed into disciplines of applied data science over the past years. Not only size and inherent complexity of the data but also requirements on data privacy and complexity of search and access pose a wealth of new research questions.

Objective

This interactive course will explore the latest research on algorithms and data structures for population scale genomics applications and give insights into both the technical basis as well as the domain questions motivating it.

Content

Over the duration of the semester, the course will cover three main topics. Each of the topics will consist of 70-80% lecture content and 20-30% seminar content.

1) Algorithms and data structures for text and graph compression. Motivated through applications in compressive genomics, the course will cover succinct indexing schemes for strings, trees and general graphs, compression schemes for binary matrices as well as the efficient representation of haplotypes and genomic variants.

2) Stochastic data structures and algorithms for approximate representation of strings and graphs as well as sets in general. This includes winnowing schemes and minimizers, sketching techniques, (minimal perfect) hashing and approximate membership query data structures.

3) Data structures supporting encryption and data privacy. As an extension to data structures discussed in the earlier topics, this will include secure indexing using homomorphic encryption as well as design for secure storage and distribution of data.

Lecture notes

Lecture slides will be available on moodle.

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data.

Abstract

Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

* epidemiology
* pathogen evolution
* macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylogenetics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or assessed. S. Frei, M. Legner, The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.

**Content**

The course will cover advanced topics in Internet routing and forwarding such as:

- Tunneling
- Hierarchical routing
- Traffic Engineering and Load Balancing
- Virtual Private Networks
- Quality of Service/Queueing/Scheduling
- Fast Convergence
- Network virtualization
- Network programmability (OpenFlow, P4)
- Network measurements

The course will be divided into two main blocks. The first block (~8 weeks) will interleave classical lectures with practical exercises and labs. The second block (~6 weeks) will consist of a practical project which will be performed in small groups (~3 students). During the second block, lecture slots will be replaced by feedback sessions where students will be able to ask questions and get feedback about their project. The last week of the semester will be dedicated to student presentations and demonstrations.

**Literature**

Relevant references will be made available through the course website.

**Credit Information**

2V+2U+3A

Concepts and Theories

Communication

Adaptability and Flexibility

Creative Thinking

Critical Thinking

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### Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
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<td>Techniques and Technologies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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### 401-3913-01L Mathematical Foundations for Finance

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<th>3V+2U</th>
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<tr>
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<th>4 credits</th>
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**Abstract**

First introduction to main modelling ideas and mathematical tools from mathematical finance

**Objective**

This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

**Content**

Topics to be covered include

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

**Lecture notes**

Lecture notes will be sold at the beginning of the course.

**Literature**

Lecture notes will be sold at the beginning of the course. Additional (background) references are given there.

**Prerequisites / notice**

Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarize themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

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### 401-3922-00L Life Insurance Mathematics

<table>
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<tr>
<th>Taught competencies</th>
<th>W</th>
<th>4 credits</th>
<th>2V</th>
</tr>
</thead>
</table>

**Abstract**

The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated.

The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

**Objective**

The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

**Content**

The following topics are treated:

- Collective Risk Modeling
- Individual Claim Size Modeling
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tarification
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

**Lecture notes**

M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
http://ssrn.com/abstract=2319328

**Literature**

M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications
http://ssrn.com/abstract=3822407

**Prerequisites / notice**

This course ONLY take place during the official ETH examination period (and they will be in person at ETH, this also applies to exchange/mobility students).

This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.
Abstract
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Content
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

Lecture notes
Slides and lecture notes will be made available.

Prerequisites / notice
Basic knowledge in statistics, probability theory, and actuarial techniques.
Content

The theoretical part of the lecture consists of the topics listed below.

- Standard Markowitz Model and Extensions MV Optimization, MV with Liabilities and CAPM.
- The Crux with MV
  Resampling, regression, Black-Litterman, Bayesian, shrinkage, constrained and robust optimization.
- Downside and Coherent Risk Measures
  Definition of risk measures, MV optimization under VaR and ES constraints.
- Risk Budgeting
  Equal risk contribution, most diversified portfolio and other concentration indices
- Regime Switching and Asset Allocation
  An introduction to regime switching models and its intuition.
- Strategic Asset Allocation
  Introducing a continuous-time framework, solving the HJB equation and the classical Merton problem.

401-8905-00L  Financial Engineering (University of Zurich)  W  6 credits  4G  University lecturers

Abstract  This lecture is intended for students who would like to learn more on equity derivatives modelling and pricing.

Objective  Quantitative models for European option pricing (including stochastic volatility and jump models), volatility and variance derivatives, American and exotic options.

Content  After introducing fundamental concepts of mathematical finance including no-arbitrage, portfolio replication and risk-neutral measure, we will present the main models that can be used for pricing and hedging European options e.g. Black-Scholes model, stochastic and jump-diffusion models, and highlight their assumptions and limitations. We will cover several types of derivatives such as European and American options, Barrier options and Variance-Swaps. Basic knowledge in probability theory and stochastic calculus is required. Besides attending class, we strongly encourage students to stay informed on financial matters, especially by reading daily financial newspapers such as the Financial Times or the Wall Street Journal.

Lecture notes  Script.

Prerequisites / notice  Basic knowledge of probability theory and stochastic calculus. Asset Pricing.

401-4889-00L  Mathematical Finance  W  11 credits  4V+2U  D. Possamaï

Abstract  Advanced course on mathematical finance:
  - semimartingales and general stochastic integration
  - absence of arbitrage and martingale measures
  - fundamental theorem of asset pricing
  - option pricing and hedging
  - hedging duality
  - optimal investment problems
  - additional topics

Objective  Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes)

Content  This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include:
  - semimartingales and general stochastic integration
  - absence of arbitrage and martingale measures
  - fundamental theorem of asset pricing
  - option pricing and hedging
  - hedging duality
  - optimal investment problems
  - and probably others

Lecture notes  The course is based on different parts from different books as well as on original research literature.

Prerequisites / notice  (will be updated later)

Literature  Prerequisites are the standard courses
  - Probability Theory (for which lecture notes are available)
  - Brownian Motion and Stochastic Calculus (for which lecture notes are available)
Those students who already attended "Introduction to Mathematical Finance" will have an advantage in terms of ideas and concepts.

This course is the second of a sequence of two courses on mathematical finance. The first course "Introduction to Mathematical Finance" (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imsf/education/education-in-stochastic-finance/overview-of-courses.html.

103-0227-00L  Application Development in Cartography  W  6 credits  4G  L. Hurni

Abstract  This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Objective  Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.
Content
- 3D cartography
- Web mapping
- Data processing
- Animations and interactions
- Map and UI design
- Web application development
- Programming (JavaScript).

Lecture notes
Handouts of the lectures and exercise documents are available on Moodle.

Prerequisites / notice
Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
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<td>Critical Thinking</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>Self-direction and Self-management</td>
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<td>Problem-solving</td>
<td>Project Management</td>
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<td>Project Management</td>
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</table>

103-0717-00L
Geoinformation Technologies and Analysis
W 6 credits 5G M. Raubal

Abstract
Geoinformationstechnologien und -analysen für Fortgeschrittene: Mobile GIS; Web-GIS & Geo-Web-Services; Spatial Big Data; Zeitliche Aspekte in GIS; Analyse von Bewegungsdaten; Benutzerschnittstellen

Objective

Content
- Mobile GIS
- Web-GIS & Geo-Web-Services
- Spatial Big Data
- Zeitliche Aspekte in GIS
- Analyse von Bewegungsdaten
- Benutzerschnittstellen

Lecture notes
Vorlesungspräsentationen werden digital zur Verfügung gestellt.

Literature

851-0760-00L
Building a Robot Judge: Data Science for Decision-Making
 Particularly suitable for students of D-INFK, D-ITET, D-MTEC
W 3 credits 2V E. Ash

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>851-0761-00L</td>
<td>Building a Robot Judge: Data Science for Decision-Making (Course Project)</td>
<td>2 credits, 2V</td>
<td>E. Ash</td>
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</tbody>
</table>

Please register only if attending the lecture course or with consent of the instructor.

Some programming experience in Python is required, and some experience with text mining is highly recommended.

Abstract

Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

Objective

In a semester paper, students (individually or in groups) will conceive and implement their own research project applying natural language tools to legal texts. Some programming experience in Python is required, and some experience with NLP is highly recommended.

Content

We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.

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<tr>
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<th>Instructor</th>
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<tbody>
<tr>
<td>851-0735-09L</td>
<td>Workshop &amp; Lecture Series on the Law &amp; Economics</td>
<td>2 credits, 2S</td>
<td>S. Bechtold</td>
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</tbody>
</table>

Abstract

This series is a joint project by ETH Zurich and the Universities of St. Gallen and Zurich. It provides an overview of interdisciplinary research on intellectual property, innovation, antitrust, privacy & technology policy. Scholars from law, economics, management and related fields present their current research. All speakers are internationally well-known experts from Europe, the U.S. & beyond.

Objective

After the workshop and lecture series, participants should be acquainted with interdisciplinary approaches towards intellectual property, innovation, antitrust, privacy and technology policy research. They should also have an overview of current topics of international research in these areas.

Content

The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.

Lecture notes

Papers discussed in the workshop and lecture series are posted in advance on the course web page.

Literature

Suzanne Scotchmer, Innovation and Incentives, 2004
Bronwyn Hall / Nathan Rosenberg (eds.), Handbook of the Economics of Innovation, 2 volumes, Amsterdam 2010

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Communication assessed
Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

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<thead>
<tr>
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<th>Semester</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>227-0421-00L</td>
<td>Deep Learning in Artificial and Biological Neuronal Networks</td>
<td>4 credits</td>
<td>B. Grewe</td>
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</tr>
</tbody>
</table>

Abstract

Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers. After this course students will be able to:

- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.
Content
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al. 2015, Silver et al., 2018). ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates of discrete communication neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes
The lecture slides will be provided as a PDF after each lecture.

Prerequisites / notice
This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0252-15L</td>
<td>Network Analysis</td>
<td>W 3</td>
<td>Particularly suitable for students of D-INFK, D-MATH</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>W 3</td>
<td>Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. Where areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection. Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency. The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory: * Empirical Research and Network Data * Macro and Micro Structure * Centrality * Roles * Cohesion</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>W 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td>W 3</td>
<td>Lecture notes are distributed via the associated course moodle.</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>851-0252-13L</td>
<td>Network Modeling</td>
<td>W 3</td>
<td>Particularly suitable for students of D-INFK and in the MSc Data Science</td>
</tr>
</tbody>
</table>

Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH. Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html
Students are required to have basic knowledge in inferential statistics, such as regression models.

Abstract
Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective
Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and tests those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and develop an understanding of how those can be fit to empirical data. This will enable students to independently address research questions from various social science fields.

Content
The following topics will be covered:

- Introduction to network models and their applications
- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models

- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)
  * Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes
Slides and lecture notes are distributed via the associated course moodle.

Literature

Prerequisites / notice
Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

851-0586-03L Applied Network Science: Social Media Networks W 3 credits 2S U. Brandes
Number of participant limited to 20

Abstract
We study applications of network science methods, this semester in the domain of social media.

Topics are selected for diversity in research questions and techniques for topics such as privacy and information spread on a variety of platforms.

Objective
Student teams present results from the recent literature, possibly with replication, in a one-day conference.

Content
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on social media, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

101-0417-00L Transport Planning Methods W 6 credits 4G K. W. Axhausen

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

Content
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Lecture notes
Moodle platform (enrollment needed)

Literature


This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models’ current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform practical transportation studies

This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:
1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.
Here the open-source agent framework used at ETH Zurich to set up agent-based models will be introduced
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

There are no strict prerequisites regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

701-0023-00L

| Atmosphere | Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer. |
| W | 3 credits |
| 2V | E. Fischer, T. Peter |

Abstract
Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Content
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Lecture notes
Written information will be supplied.

Literature

Prerequisites / notice
No strict prerequisites. Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

701-0473-00L

| Weather Systems | Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes |
| W | 3 credits |
| 2G | M. A. Sprenger, F. Scholder-Aemisegger |

Abstract
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Objective
The students are able to
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems

Content
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Lecture notes
Lecture notes and slides

Literature
- Atmospheric Science, An Introductory Survey
  John M. Wallace and Peter V. Hobbs, Academic Press
- MATSim

Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

701-1251-00L

| Land-Climate Dynamics | Number of participants limited to 36. The target groups are the following:
  - PHD student Environmental sciences
  - MSc in Atmospheric and climate science
  - MSc in Environmental sciences

| W | 3 credits |
| 2G | S. I. Seneviratne, R. Padrón Flasher, P. Sieber |

Abstract
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

Objective
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Powerpoint slides will be made available
### Data Science Lab

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>263-3300-00L</td>
<td>Data Science Lab</td>
<td>O</td>
<td>14 credits</td>
<td>9P</td>
<td>C. Zhang, V. Boeva, R. Cotterell, A. Ilic, J. Vogt, F. Yang</td>
</tr>
</tbody>
</table>

#### Abstract
In this class, we bring together data science applications provided by ETH researchers outside computer science and teams of computer science master’s students. Two to three students will form a team working on data science/machine learning-related research topics provided by scientists in a diverse range of domains such as astronomy, biology, social sciences etc.

#### Objective
The goal of this class if for students to gain experience in dealing with data science and machine learning applications “in the wild”. Students are expected to go through the full process starting from data cleaning, modeling, execution, debugging, error analysis, and quality/performance refinement.

#### Prerequisites / notice
Prerequisites: At least 8 KP must have been obtained under Data Analysis and at least 8 KP must have been obtained under Data Management and Processing.

### Seminar

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>252-5051-00L</td>
<td>Advanced Topics in Machine Learning</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Cotterell, N. He, F. Yang, M. Elassady</td>
</tr>
</tbody>
</table>

#### The deadline for deregistering expires at the end of the fourth week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

#### Abstract
In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover statistical models in computer vision, graphical models and machine learning.

#### Objective
The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.

#### Content
The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

#### Literature
The papers will be presented in the first session of the seminar.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-3504-00L</td>
<td>Hardware Acceleration for Data Processing</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>G. Alonso</td>
</tr>
</tbody>
</table>

#### The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

#### Abstract
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

#### Objective
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

#### Content
The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

#### Prerequisites / notice
Students taking this seminar should have the necessary background in systems and low level programming.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-3713-00L</td>
<td>Advanced Topics in Human-Centric Computer Vision</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>O. Hilliges</td>
</tr>
</tbody>
</table>

#### The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

#### Abstract
In this seminar we will discuss state-of-the-art literature on human-centric computer vision topics including but not limited to human pose estimation, hand and eye-gaze estimation as well as generative modelling of detailed human activities.

#### Objective
The learning objective is to analyze selected research papers published at top computer vision and machine learning venues. A key focus will be placed on identifying and discussing open problems and novel solutions in this space. The seminar will achieve this via several components: reading papers, technical presentations, writing analysis and critique summaries, class discussions, and exploration of potential research topics.
The goal of the seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and oral presentation skills. The seminar will have a different structure from regular seminars to encourage more discussion and a deeper learning experience.

We will treat papers as case studies and discuss them in-depth in the seminar. Once per semester, every student will have to take one of the following roles:

Presenter: Give a presentation about the paper that you read in depth.
Reviewer: Perform a critical review of the paper.
All other students: read the paper and submit questions they have about the paper before the presentation.

Prerequisites / notice
Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.

Taught competencies
<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
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</thead>
<tbody>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
</tr>
</tbody>
</table>

263-5100-00L Topics in Medical Machine Learning
Number of participants limited to 18.
The deadline for deregistering expires at the end of the fourth week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold a presentation and lead the subsequent discussion.

Objective
Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.

Content
The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

Prerequisites / notice
Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

401-3620-20L Student Seminar in Statistics: Inference in Some Non-Standard Regression Problems
Number of participants limited to 24.
Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics. Also offered in the Master Programmes Statistics resp. Data Science.

Abstract
Review of some non-standard regression models and the statistical properties of estimation methods in such models.

Objective
The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).

Content
Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, linearity might be too simplistic to capture the actual relationship between some response and given covariates. Also, there are many real data problems where linearity is plausible but the actual pairing between the observed covariates and responses is completely lost or at partially. In this seminar, we review some of the non-classical regression models and the statistical properties of the estimation methods considered by well-known statisticians and machine learners. This will encompass:
1. Monotone regression
2. Single index model
3. Unlinked regression

Autumn Semester 2022
Literature

In the following is the tentative material that will be read and studied by each pair of students (all the items listed below are available through the ETH electronic library or arXiv). Some of the items might change.

8. "Linear regression with shuffled data: statistical and computation limits of permutation recovery" by A. Pananjady, M. Wainwright and T. A. Courtade , 2018, IEEE transactions in Information Theory, Volume 64, 3286-3300
9. "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS
11. "Uncoupled isotonic regression via minimum Wasserstein deconvolution" by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27

Prerequisites / notice

The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

401-5680-00L Foundations of Data Science Seminar E- 0 credits P. L. Bühlmann, A. Bandeira, H. Bölcskei, S. van de Geer, F. Yang

Abstract

Research colloquium

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-INFK

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>261-0800-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

The minimal prerequisites for the Master's thesis registration are:

Completed Bachelor's program
All additional requirements completed (additional requirements, if any, are listed in the admission decree)
Minimum degree requirements fulfilled of the course categories Data Analysis and Data Management and overall 50 credits obtained in the course category Core Courses
Data Science Lab (14 credits) completed

Abstract

The Master's thesis concludes the study program and demonstrates the students' ability to use the knowledge and skills acquired during Master's studies to solve a complex data science problem.

Objective

To work independently and to produce a scientifically structured work.

Data Science Master - Key for Type

| Dr | Suitable for doctorate | W | Eligible for credits |
| E- | Recommended, not eligible for credits | W+ | Eligible for credits and recommended |
| O  | Compulsory              | Z  | Courses outside the curriculum |

Key for Hours

V lecture
G lecture with exercise
U exercise
S seminar
K colloquium
P practical/laboratory course
A independent project
D diploma thesis
R revision course / private study

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. Participants will study the fundamentals of machine and deep learning, and the course includes theory and algorithms for SciML, as well as practical assignments and a final project assessment. The topics to be covered include:

1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation, and testing pipelines for academic and research projects
4. Define, Plan, Conduct and Present a SciML project
5. 10 steps to make participants' research projects more societally relevant

Throughout the course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges. Literature will be made available to the participants.

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course. Further, this collection of tools will be used in the course to complement the lecture content.

The following open access article builds a core element of the course:


available at (open access): http://www.ingentaconnect.com/content/oekom/gaia/2017/00000026/00000001/art00011

The following open access book is recommended reading for the course:


The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC. Participation in the course requires participants to be working on their own research project.
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship. In particular, the aims of the course are to:

1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a “lecture-style” approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam. These course materials will form the point of departure for the lectures, class discussions and team work.

<table>
<thead>
<tr>
<th>064-0005-22L</th>
<th>Advanced Topics in History and Theory of Architecture</th>
<th>W</th>
<th>1 credit</th>
<th>1K</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Architecture doctoral program only.</td>
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</tbody>
</table>

**Abstract**
Corrective historiographies for architectural research

**Objective**
Acquiring insight into advanced research methods available to PhD-researchers in the fields of the history and theory of art and architecture.

**Content**
In an era of postcolonial theory and reflection, architectural historiography is faced with a series of new challenges and ambitions, concerning its subjects and its methods.

This course will reflect upon three of them: the death of the author, center and meta-theory. A first point investigates how recent scholarship seems to dissociate from histories of single and all-decisive authors, to make way for perspectives that render buildings and neighborhoods as a matter of negotiation between multiple agencies. Second, this course will dwell upon the Euro-American bias of our histories, as well as its implicit center-periphery model, and look at recent attempts to tell more cross-cultural historiographies of architecture. Third, the course will discuss the strong meta-theoretical bias of postcolonial historiography (using theories of power, alterity, gender) and question if this has not resulted in disqualification of the material and formal presence of architecture in our history writing.

This threefold change in architectural historiography seems to coincide with a shift in the contemporary discourses on the changing role of the architect, the cooperative character of architectural practice and the renewed interest in the craft. The course will question the productiveness of these resonances between historiography and design practice.

**Lecture notes**
Scans of selected texts for discussion and exercises will be provided at the beginning of HS 2022 on the course website:

**Literature**

**Prerequisites / notice**
The seminar addresses the fellows of the Doctoral Program in History and Theory of Architecture. All other doctoral students of the Faculty of Architecture are welcome.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<tr>
<td>Problem-solving</td>
<td>not assessed</td>
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<tr>
<td>Project Management</td>
<td>not assessed</td>
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<tr>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<tr>
<td>Negotiation</td>
<td>assessed</td>
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<tr>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>
Research Methods in the History and Theory of Architecture

W 2 credits 2S C. Rachele

Abstract
Introduction to methodological approaches in the history and theory of architecture; presentation and discussion of individual doctoral projects.

Objective
The two-semester course in the first year of the doctoral program in the history and theory of architecture has a twofold objective: First, method sessions on central approaches in the history and theory of architecture provide a methodological basis for the doctorate at the Institute gta. Secondly, in "practice" sessions, the doctoral students get support for their individual research projects and guidance for the production of the Research Plan they have to present at the end of the first year.

Content
"Again. If a thing can be done adequately by means of one, it is superfluous to do it by means of several; for we observe that nature does not employ two instruments where one suffices."

The methodology of humanistic research grows more complex with every academic generation: it presents a complex thicket of epistemological frameworks and practical strategies rather than a straightforward array of tools. In the omnivorous field of architectural history and theory, the scholar faces a yet more multi-faceted array of possible approaches to any individual research subject. This course considers the variety of available strategies for the creation of architectural histor(ies) and theor(ies) as an opportunity for intellectual inquiry distinctive to our discipline. Through close and prolonged study of a range of historically significant or methodologically innovative writing, we will deepen our understanding both of how other historians have structured their work as well as refine each student's developing research methodology.

The course, held over two semesters, combines a traditional doctoral theory seminar with a practical writing workshop: we will alternate reading-based discussions with working sessions directed towards the development of the research proposal to be submitted at the end of the first year.

Due to the intensive nature of the course, active class participation is required for doctoral students and all in-presence attendees. Students attending individual sessions in a listening capacity are requested to utilize the hybrid option.

The course schedule will be available at the beginning of HS 2021 on the course website: https://doctoral-program.gta.arch.ethz.ch/courses/research-methods

Please note doctoral program courses begin the third week of the semester.

Lecture notes
Scans of selected texts for discussion and exercises will be provided at the beginning of HS 2022 on the course moodle page: https://moodle-app2.let.ethz.ch/course/view.php?id=15873

Taught competencies

<table>
<thead>
<tr>
<th>Taught Competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative thinking</td>
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<td>not assessed</td>
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<tr>
<td></td>
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<td>not assessed</td>
<td>not assessed</td>
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</table>

PhD Colloquium Theory of Information Technology for Architects

W 2 credits 2K L. Hovestadt

Abstract
Information technology plays an increasingly important role in research. To meet this challenging development, it is not only important to acquire respective skills, but also to consider and understand information technology in what sets it apart from other gestalts of technics (like mechanics, dynamics, or thermodynamics).

Objective
The aim of this colloquium is to counter an observable tendency, that proportional to the degree in which students master practical skills in computing, they increasingly submit uncritically, in their understanding and framing of problems, to the dictation of schemata and templates implemented by technical systems.

Content
The starting point for this colloquium is to comprehend computing not in terms of skills, but as a literacy which we can experience emerging today. Like in the case of writing as well, computing cannot exhaustively be reduced to either logics, grammar, arithmetics, or analytics. Rather, computation, if comprehended as a literacy, relates to any of the established categories of learning and raises questions of an architectonic kind. This colloquium draws from the principal richness of cultural forms of knowing and learning and thematizes approaches to formulate a theoretical stance on information technology for architects which is driven by and resting on the actual reality of computability today. In this, it is complementary to those theory courses on technology offered by the historical disciplines at ETH.

Prerequisites / notice
To benefit from this course, you should have a practical affinity to technics, as well as an abstract interest in information technology in its comprehensive cultural context.

Research Methods in Landscape and Urban Studies: Writing Landscapes, Writing the Urban


Abstract
This seminar supports researchers writing on topics related to landscape, urban studies, and architecture through offering hands-on guidance and a safe space for peer-to-peer exchange. The seminar participants receive guidance on how to work with fieldwork, literature reviews, and archival research, develop arguments and narrative arcs in writing.
Introduction to Computational Research in Architecture, Engineering, Fabrication and Construction

Does not take place this semester.

Objective

Research writing can often be a solitary, arduous, and unrewarding exercise, this seminar aims to promote peer-to-peer exchange, and offer hands-on guidance and a safe space for researchers writing on topics related to landscape, urban studies, and architecture. The seminar will offer guidance as to how researchers can work with fieldwork, literature reviews, and archival research, develop arguments and narrative arcs in writing, in addition to practical tips and tricks. While the seminar is primarily geared towards supporting doctoral researchers in the dissertation-writing phase, it is open to all researchers regardless of where they might be in their research provided they are in the process of developing a work of academic writing such as research plan, a journal article, or a design manifesto.

The participants of this seminar are expected to bring a text that they would like to develop over the course of the semester. The texts can be diverse in format and length; it can be a dissertation or book chapter, journal or magazine article, or a research plan.

The seminar will alternate between inputs by invited guests, reading and discussion sessions, tutorials, and peer-review. A total of five input lectures by invited guests will be offered during the seminar, where senior academics from the Department and elsewhere will provide a behind-the-scenes look into their writing process. The invited guests will discuss as to how they structure their arguments, organise their sources and materials, and how they find inspiration for their writing process. These input lectures will be alternated with thematically organised tutorial sessions structured around the following themes: writing about fieldwork and field methods, about landscapes, about political ecology and economy, ethnographic human and other-than-human vignettes, about dwelling and urban space. In the first half of these tutorial sessions, the seminar participants will discuss and debate a requisite reading followed by a writing tutorial and feedback session based on the texts. The seminar participants can choose to present the work developed during the seminar at the LUS Doctoral Crits organised at the end of the semester.

Content

The format will provide an overarching methodological meta-theme, to be defined prior to the event. One external guest critic will be invited.

In this case, each presentation will conclude with a discussion round, providing sufficiently detailed feedback for every doctoral candidate.

Lecture notes

22.09 – EXERCISES IN STYLE

29.09 – Ethnography from the field and archive – ADAM JASPER
06.10 – Writing spatially, writing otherwise - MATTHEW CRITCHLEY
13.10 – Indigenous Landscape Urbanism - KELLY SHANNON
03.11 – Informed gardening activism - BARBARA VAN DYCK
10.11 – Ordering the unfamiliar - ANNE HULTZSCH
17.11 – Landscape, dwelling, and the political ecology - MAAN BARUA
24.11 – From notes to narrative - NIKOS MAQOULIOTIS
01.12 – Imagining the invisible - NANCY COULING
08.12 – Writing in the Planetary Age - HOLLYAMBER KENNEDY
15.12 – LUS Doc Crits

Literature


The seminar is joint-organized by the chairs of the professors H. Klumpner, Ch. Girot, G. Vogt and M. Angélil (who in HS18 is mainly responsible for the course (one full-day event in the academic semester).

Participants in both cases will be expected to submit single-page abstracts of their papers in advance and to make a presentation of app. 20 minutes at the colloquium. The discussion rounds will be moderated by the organizing professor and the invited guests.

Enrolment on agreement with the lecturer only.
Abstract

The PhD-level course (primarily for A&T PhDs) will introduce computational methods for architecture, engineering, fabrication & construction, incentivising computational literacy. Students learn the theoretical background and basic implementation details of fundamental data structures and algorithms, and to solve real-world problems using the COMPAS framework and other open-source libraries.

Objective

Understand the scope and relevance of computational methods for architecture and engineering research and practice. i) the theoretical background of fundamental data structures, ii) the basic principles of algorithmic design, iii) implement basic versions of prevalent algorithms related to architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation; iv) use sophisticated algorithms available through open-source libraries to solve real-world problems; and, v) use common CAD tools as interfaces to self-implemented solutions.

Content

Course consists of a few lectures, several tutorials and project-based exercises. Topics include:
- intro Python programming
- intro COMPAS open-source framework (https://compas-ev.github.io)
- intro to geometry processing, data structures, topology, numerical computation
- domain-specific case studies (e.g. on architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation)

Prerequisites / notice

Priority is given to PhD students.

064-0027-22L  
PhD Colloquium CASA (Institute IEA)  
W 2 credits 2K  
E. Mosayebi

052-0835-22L  
Summer School: Tentacular Writing - A Peer-to-Peer Writing Retreat (ETH-EPFL)  
For MSc ARCH students and Doctoral students.

Abstract

The summer school intends to renegotiate and experiment with the ways we – as researchers and spatial practitioners – perform writing, as a format and as a practice. In the set-up of a collective retreat in the Swiss Alps, in a non-hierarchical learning format, a group of peers is invited to shape an academic community, work alongside and discuss their work-in-progress informally.

Objective

The summer school aspires to establish a peer group of early-career scholars that stay connected beyond the summer school. By the end of the workshop, the participants will have:
- acquired skills on new writing methods
- discussed learning and writing outcomes collectively
- gained the opportunity to take the role of an editor of their colleagues work
- gained experience in presenting their work-in-progress in an informal setting

Content

The programme foresees a summer school in the form of a collaborative writing retreat. The participants are expected to take their individual research as a starting point and develop it further during their stay. Selected invited experts will host writing workshops on themes like creative writing, site writing and multi-perspectival writing. Additionally, two sensorial workshops hosted by artists on the themes of sound and smell aim to inspire and enrich the writing practice and connect the participants to the place. All workshops will serve as input sessions and are followed by individual writing periods, where participants get the chance to test the methods acquired in the expert workshops. Individual writing sessions are then followed by group sessions where the material is collectively discussed. The format aims at generating a non-hierarchical learning environment, a peer group where colleagues collectively progress their writing by exploring new methods and perspectives.

The summer school is articulated through the synthesis of three different formats:
- workshops organized by external guests offering inputs to the participant
- individual writing sessions for the participants to develop their material
- collective peer-to-peer discussion aiming at exchange and the formation of a peer-group

Writing Workshops
Room and Field, Writing One with Another: a Site-Writing Workshop with Jane Rendell and Polly Gould
Exploring Sensorial Practices
Writing with sound, by Ludwig Berger, sound artist
Follow your nose, by Curdin Tones, community-artist

With Collective Cooking Sessions and Fountain Bathing curated by the community-artist Curdin Tones

Lecture notes

Teaching involves 3 full workshop days, 1 self-study day and one final review day.

Place: The summer is organized at the Alpine village of Tschlin in Graubünden, Switzerland. Participants will be hosted at three local houses. Common workshops will be organized at the venue of the local school and at the artistic residency space of Somalgors74.

The summer school explores a form of inhabitation that is neither touristic nor individual and allows for reflection and redefinition of what it means to retreat: We want to see retreating not as isolating and detouching but rather as engaging with localities and situating ourselves.

Date: The summer school will take place on 11 – 16 September 2022.

Organisers
Metaxia Markaki (ETHZ), Johanna Just (ETHZ), Sila Karatas (EPFL)

Prerequisites / notice

Participation fees cover accommodation and selected meals (all lunches and 2 dinners):
250CHF (ETHZ/EPFL doctoral students), 350CHF external doctoral students; ETHZ/EPFL Mitteiabau with a strong interest in writing.

All participants are required to take part in the full 6 day programme. (Arrival 11.9, programme 12-16.9) Applicants will submit a writing sample related to their dissertation and a CV.

Data: 18.08.2022 12:39  
Autumn Semester 2022  
Page 612 of 2345
This planned course addresses the crucial urban transformation issues of our time at the 10-minute-neighbourhood level. Technology, Transferable Skills Course I (1-3 days)
  Analytical Competencies assessed
  Communication not assessed
  Concepts and Theories assessed
  Techniques and Technologies not assessed
  Decision-making assessed
  Media and Digital Technologies not assessed
  Problem-solving assessed
  Project Management not assessed
  Social Competencies Communication assessed
  Cooperation and Teamwork assessed
  Leadership and Responsibility not assessed
  Self-presentation and Social Influence assessed
  Sensitivity to Diversity assessed
  Negotiation assessed
  Personal Competencies Adaptability and Flexibility assessed
  Creative Thinking assessed
  Critical Thinking assessed
  Integrity and Work Ethics assessed
  Self-awareness and Self-reflection assessed
  Self-direction and Self-management assessed

052-0727-22L 4D-Geodesigning Urban Transformation - Summer School
  Is offered until end of FS23. This summer school is suitable for Master and doctoral students only. Please register before 6.6.22.

Abstract
The project addresses critical issues of urban planning by using cutting-edge technology for analysis and communication. Students actively engage with building and zoning regulations (i) reconstruct, (ii) reformulate and (iii) simulate/virtualise in web-based 4D urban models as well as maintain an ongoing exchange through (peer) review activities in class.

Objective
- Capture and analyse the past and present; design, present and discuss future living spaces in 4D.
- Read, understand, deconstruct and formulate new zoning and building rules (BNO)’s.
- Set up an ArcGIS Urban model and integrate current and new urban rules and visualize/simulate development scenarios/variations of urban designs.
- Learn from students from different disciplines through teamwork and by peer-reviewing each other’s work.
- System thinking through causal loops.

Content
This planned course addresses the crucial urban transformation issues of our time at the 10-minute-neighbourhood level. Technology, communication and online learning materials are leveraged and opportunities for online interaction are combined with traditional place-based teaching methods. The course can be taught as elective with exercise and as an integrated discipline in design classes. In addition, the online material can be used for self-paced learning.

(i) Students actively engage with building and land use regulations by reconstruction them in a 3D model, formulating new 3D regulations based on design and land use criteria, and simulating possible developments based on existing building criteria in 4D. As students from different disciplines work in teams and share knowledge through mutual work and peer reviews, they can learn from each other across disciplines.

(ii) Urban design lecturers can benefit from being relieved of the task of teaching students software as part of the design class.

(iii) The entire degree programmes in architecture, landscape architecture, building information systems (all D-ARCH), and spatial development and infrastructure systems (D-BAUG) can benefit from this. It is also conceivable that, building on this, a joint program will be developed and offered in the future, with the integration/combination of City Energy Analysis (CEA) by Prof. Schlüter, IÖ-app by Prof. Menz, Enerpol Tool/Daylight by Prof. Klumpner, to name but a few.

Prerequisites / notice
The course is offered in summer 2022 as an elective block course with exercises, in HS22 as an integrated discipline within the Klumpner design studio and in FS23 to choose between the elective course or the integrated discipline.

Places: 20 at the most
Group work: groups of two
Primary target groups: Master Architecture, Integrated Building Systems, Landscape Architecture, Master Spatial Development and Infrastructure Systems, PhD D-ARCH, PhD D-BAUG
Registration: until 06.06.2022
Waiting list: until 17.06.2022

► Transferable Skills

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 614 of 2345
Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL Transferable Skills Course II (min 4 days, with Poster or Talk)
Only for doctoral students.

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Objective
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900-0111-DRL Transferable Skills Course III (min 4 days, with Poster or Talk)
Only for doctoral students.

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Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year)
Only for doctoral students.

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Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

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Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0151-DRL | Summer School II (1-3 days) | W    | 1    | 2K    | Lecturers |

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Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0152-DRL | Summer School III (1-3 days) | W    | 1    | 2K    | Lecturers |

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Participation in summer or winter schools with a maximum duration of 3 days.

Objective  
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Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0162-DRL  External Conference I (incl. Poster or Talk)  W  1 credit  2K  Lecturers

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0163-DRL  External Conference II (incl. Poster or Talk)  W  1 credit  2K  Lecturers

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
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900-0164-DRL  External Conference III (incl. Poster or Talk)  W  1 credit  2K  Lecturers

Abstract
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Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Doctorate Architecture - Key for Type

O  Compulsory  E-  Recommended, not eligible for credits
W+  Eligible for credits and recommended  Z  Courses outside the curriculum
W  Eligible for credits  Dr  Suitable for doctorate

Key for Hours

V  lecture  P  practical/laboratory course
G  lecture with exercise  A  independent project
U  exercise  D  diploma thesis
S  seminar  R  revision course / private study
K  colloquium

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
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<td>101-0191-00L</td>
<td>Seismic and Vibration Isolation</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>M. Vassiliou</td>
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**Abstract**
This course will cover the analysis and design of isolation systems to mitigate earthquakes and other forms of vibrations. The course will cover:
1. Conceptual basis of seismic isolation, seismic isolation types, mechanical characteristics of isolators.
3. Design approaches and code requirements

**Objective**
After successfully completing this course the students will be able to:
1. Understand the mechanics of and design isolator bearings.
2. Understand the dynamics of and design an isolated structure.

**Content**
1. Introduction: Overview of seismic isolation; review of structural dynamics and earthquake engineering principles. Viscoelastic behavior.
2. Linear theory of seismic isolation
3. Types of seismic isolation devices - Modelling of seismic isolation devices – Nonlinear response analysis of seismically isolated structures in Matlab
4. Behavior of rubber isolators under shear and compression
5. Behavior of rubber isolators under bending
6. Buckling and stability of rubber isolators
7. Code provisions for seismically isolated buildings

**Lecture notes**
The electronic copies of the learning material will be uploaded to ILIAS and available through myStudies. The learning material includes:
- reading material, and (optional) exercise problems and solutions.

**Literature**
There is no single textbook for this course. However, most of the lectures are based on parts of the following books:
- Dynamics of Structures, Theory and Applications to Earthquake Engineering, 4th edition, Anil Chopra, Prentice Hall, 2017
- Design of seismic isolated structures: from theory to practice, Farzad Naeim and James M. Kelly, John Wiley & Sons, 1999
- Mechanics of rubber bearings for seismic and vibration isolation, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011

**Prerequisites / notice**
101-0157-01 Structural Dynamics and Vibration Problems course, or equivalent, or consent of the instructor. Students are expected to know basic modal analysis, elastic spectrum analysis and basic structural mechanics.

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<td>101-0522-10L</td>
<td>Doctoral Seminar Data Science and Machine Learning in Civil, Env. and Geospatial Engineering</td>
<td>W</td>
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<td>1S</td>
<td>M. J. Van Strien, E. Chatzi, F. Corman, I. Hajnsek, M. A. Kraus, M. Lukovic, V. Ntertimanis, K. Schindler, B. Soja</td>
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**Abstract**
Current research in machine learning and data science within the research fields of the department. The goal is to learn about current research projects at our department, to strengthen our expertise and collaboration with respect to data-driven models and methods, to provide a platform where research challenges can be discussed, and also to practice scientific presentations.

**Objective**
- learn about discipline-specific methods and applications of data science in neighbouring fields
- network people and methodological expertise across disciplines
- establish links and discuss connections, common challenges and disciplinesspecific differences
- practice presentation and discussion of technical content to a broader, less specialised scientific audience

**Content**
Current research at D-BAUG will be presented and discussed.

**Prerequisites / notice**
This doctoral seminar is intended for doctoral students affiliated with the Department of Civil, Environmental and Geomatic Engineering. Other students who work on related topics need approval by at least one of the organisers to register for the seminar.
Participants are expected to possess elementary skills in statistics, data science and machine learning, including both theory and practical modelling and implementation. The seminar targets students who are actively working on related research projects.

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<td>Fatigue and Fracture in Materials and Structures</td>
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<td>A. Taras</td>
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**Abstract**
The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

**Objective**
In this course, the students will learn:
- Linear elastic and plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainfall analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and “Laboratory Competition”. The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- “Laboratory Competition” at Empa: the students with the closest predictions will win the “Empa Laboratory Competition” and will be awarded by a prize.

Lecture notes are based on the lecture slides and the handouts, which will be given to the students during the semester.

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

101-0139-00L Scientific Machine and Deep Learning for Design and Construction in Civil Engineering

W 3 credits 4G M. A. Kraus, D. Griego, R. Rust

Content
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

Lecture notes
The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Literature
Suggested Reading:
Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
S. Guido, A. Müller: Introduction to machine learning with python, O'Reilly Media, 2016
G. Martin: Bayesian analysis with python, Packt Publishing Ltd, 2016

Prerequisites / notice
Familiarity with MATLAB and / or Python is advised.

701-0015-00L Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement

W 2 credits 2S B. Vienni Baptista, C. E. Pohl, M. Stauffacher

Abstract
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

The seminar covers the following topics:

1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

Literature

The following open access article builds a core element of the course:


Further, this collection of tools will be used

https://naturalsciences.ch/topics/co-producing_knowledge

Prerequisites / notice

Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

Subject-specific Competencies

- Concepts and Theories
- Problem-solving
- Cooperation and Teamwork
- Critical Thinking
- Self-awareness and Self-reflection

Method-specific Competencies

- Sensitivity to Diversity
- Technology

Personal Competencies

- Critical Thinking
- Self-awareness and Self-reflection

Frontiers in Machine Learning Applied to Civil, Env. and Geospatial Engineering (HS22)

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Abstract

This doctoral seminar organised by the D-BAUG platform on data science and machine learning aims at discussing recent research papers in the field of machine learning and analyzing the transferability/adaptability of the proposed approaches to applications in the field of civil and environmental engineering (if possible and applicable, also implementing the adapted algorithms).

Objective

Students will

- Critically read scientific papers on the recent developments in machine learning
- Put the research in context
- Present the contributions
- Discuss the validity of the scientific approach
- Evaluate the underlying assumptions
- Evaluate the transferability/adaptability of the proposed approaches to own research
- (Optionally) implement the proposed approaches

Content

With the increasing amount of data collected in various domains, the importance of data science in many disciplines, such as infrastructure monitoring and management, transportation, spatial planning, structural and environmental engineering, has been increasing. The field is constantly developing further with numerous advances, extensions and modifications.

The course aims at discussing recent research papers in the field of machine learning and analyzing the transferability/adaptability of the proposed approaches to applications in the field of civil and environmental engineering (if possible and applicable, also implementing the adapted algorithms).

Each student will select a paper that is relevant for his/her research and present its content in the seminar, putting it into context, analyzing the assumptions, the transferability and generalizability of the proposed approaches. The students will also link the research content of the selected paper to the own research, evaluating the potential of transferring or adapting it. If possible and applicable, the students will also implement the adapted algorithms. The students will work in groups of up to three students, where each of the three students will be reading each other's selected papers and providing feedback to each other.

Prerequisites / notice

This doctoral seminar is intended for doctoral students affiliated with the Department of Civil, Environmental and Geomatic Engineering. Other students who work on related topics need approval by at least one of the organisers to register for the seminar.

Participants are expected to possess elementary skills in statistics, data science and machine learning, including both theory and practical modelling and implementation. The seminar targets students who are actively working on related research projects.
Taught competencies

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

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

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

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

Transferable Skills

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**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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**900-0106-DRL Transferable Skills Course I (min 4 days)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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**900-0106-DRL Transferable Skills Course I (min 4 days)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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**900-0108-DRL Transferable Skills Course II (min 4 days)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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**900-0108-DRL Transferable Skills Course II (min 4 days)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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**900-0109-DRL Transferable Skills Course III (min 4 days)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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**900-0109-DRL Transferable Skills Course III (min 4 days)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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**900-0110-DRL Transferable Skills Course I (min 4 days, with Poster or Talk)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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**900-0110-DRL Transferable Skills Course I (min 4 days, with Poster or Talk)**

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**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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**900-0111-DRL Transferable Skills Course III (min 4 days, with Poster or Talk)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

---

**900-0112-DRL Participation in Commission I (min 1 year)**

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**Objective**

Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.
### Participation in Commission II (min 1 year)

- **W** 1 credit 2P Lecturers

**Abstract**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**Objective**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

### Member of Executive Board (min 1 year)

- **W** 2 credits 4P Lecturers

**Abstract**
Active participation in the presidium or executive board of a university group for at least 1 year.

**Objective**
Active participation in the presidium or executive board of a university group for at least 1 year.

### Ethics and Scientific Integrity for Doctoral Students

- **W** 1 credit 2U G. Achermann, E. Bobst, N. Gruber, E. Vayena

**Abstract**
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

**Objective**
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

**Content**

<table>
<thead>
<tr>
<th>Part I on Moodle</th>
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</thead>
<tbody>
<tr>
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<td><strong>Module 1: Ethics</strong></td>
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<td>- Introduction to moral theory (with emphasis on practical guidance regarding decision making)</td>
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<td><strong>Module 2: Ethics in scientific research</strong></td>
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<td>- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).</td>
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<td><strong>Module 3: Collecting resources</strong></td>
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<tr>
<td>- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).</td>
</tr>
</tbody>
</table>

**Part II**
The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

**Prerequisites / notice**
For doctoral students only.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
<tr>
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**Language Courses ETH/UZH:** see Science in Perspective

### Ethics and Scientific Integrity for Doctoral Students of D-BAUG

- **W** 1 credit 1S C. Sailer

**Abstract**
This course sensitises doctoral students to ethical issues that may arise during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students are given the opportunity to apply their knowledge and train their newly acquired skills in an interactive, discipline specific context.

**Objective**
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. Furthermore, they are encouraged to reflect on their professional role as scientific researchers.

---

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 623 of 2345
Part I
The self-paced e-learning course consists of 5 modules:

Module 1: Ethics
Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices or solve ethical dilemmas).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects in the general area of Environmental Sciences. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only

Taught competencies

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Integration into Scientific Community

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<tr>
<th>Number</th>
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<td>900-0150-DRL</td>
<td>Summer School I (1-3 days)</td>
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Objective
Participation in summer or winter schools with a maximum duration of 3 days.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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**External Conference III (incl. Poster or Talk)**

Only for doctoral students.

*Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.*

**Abstract**

Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Objective**

Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

---

### Doctorate Civil, Environmental and Geomatic Engineering - Key for Type

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

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

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Subject Specialisation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>376-1791-00L</td>
<td>Introductory Course in Neuroscience I (University of Zurich)</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: SPV0Y005</td>
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<tr>
<td></td>
<td>Mind the enrolment deadlines at UZH:</td>
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<tr>
<td>Abstract</td>
<td>The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.</td>
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<tr>
<td>Objective</td>
<td>The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.</td>
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<tr>
<td>Content</td>
<td>1) Human Neuroanatomy I&amp;II</td>
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<td></td>
<td>2) Comparative Neuroanatomy</td>
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<td></td>
<td>3) Building a central nervous system I,II</td>
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<td></td>
<td>4) Synapses I,II</td>
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<td></td>
<td>5) Glia and more</td>
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<td></td>
<td>6) Excitability</td>
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<td></td>
<td>7) Circuits underlying Emotion</td>
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<td>8) Visual System</td>
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<td></td>
<td>9) Auditory &amp; Vestibular System</td>
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<td></td>
<td>10) Somatosensory and Motor Systems</td>
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<td></td>
<td>11) Learning in artificial and biological neural networks</td>
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<td>151-0927-00L</td>
<td>Rate-Controlled Separations in Fine Chemistry</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>M. Mazzotti, V. Becattini</td>
</tr>
<tr>
<td>Abstract</td>
<td>The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.</td>
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<tr>
<td>Objective</td>
<td>The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.</td>
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</tr>
<tr>
<td>Content</td>
<td>The class covers separation techniques that are central in the purification and downstream processing of chemicals and bio-pharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts during the class</td>
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<td>Recommendations for text books will be covered in the class</td>
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<td>Prerequisites / notice</td>
<td>Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)</td>
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<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
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<tr>
<td></td>
<td>Concepts and Theories</td>
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<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
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<td></td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td></td>
<td></td>
<td></td>
<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
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<td>assessed</td>
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<td></td>
<td>Project Management</td>
<td></td>
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<td></td>
<td>not assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>assessed</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>not assessed</td>
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<td></td>
<td>Customer Orientation</td>
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<td>not assessed</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
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<td></td>
<td>not assessed</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td>not assessed</td>
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<td></td>
<td>Sensitivity to Diversity</td>
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<td></td>
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<td></td>
<td>Negotiation</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Creative Thinking</td>
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<td></td>
<td></td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td></td>
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<td></td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td></td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
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<td></td>
<td></td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
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<td></td>
<td></td>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<tr>
<td>Objective</td>
<td>The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.</td>
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<tr>
<td>Content</td>
<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies. The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.</td>
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<tr>
<td>Lecture notes</td>
<td>A script will be available.</td>
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</tbody>
</table>
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

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

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Problem-solving: assessed
- Project Management: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Prerequisites / notice

This is no lecture. There is no exam and no credit points will be awarded. The current program can be found on the web: http://stat.ethz.ch/events/zukost

Course language is English or German and may depend on the speaker.

Seminars by invited speakers covering selected microbiology themes.

Contact: beratung@stat.math.ethz.ch . Tel. 044 632 2223. See also http://stat.ethz.ch/consulting

Requirements: Knowledge of the basic concepts of statistics is desirable.

The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.
The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

Presentations will be made available after the seminars.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor(s)</th>
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<tr>
<td>551-0737-00L</td>
<td>Ecology and Evolution: Interaction Seminar</td>
<td>2</td>
<td>S. Bonhoeffer</td>
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<tr>
<td>551-0509-00L</td>
<td>Current Immunological Research in Zurich</td>
<td>0</td>
<td>D. Hall, M. Kopf, S. R. Leibundgut, A. Oxenius, University lecturers</td>
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<tr>
<td>551-1615-00L</td>
<td>NMR Methods for Studies of Biological Macromolecules</td>
<td>1</td>
<td>A. D. Gossett</td>
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<tr>
<td>551-1409-00L</td>
<td>RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics</td>
<td>4</td>
<td>J. Hall, M. Staffel, further lecturers</td>
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<tr>
<td>551-1407-00L</td>
<td>RNA Biology Lecture Series I: Transcription &amp; Processing &amp; Translation</td>
<td>4</td>
<td>F. Allain, N. Ban, U. Kutay, further lecturers</td>
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<tr>
<td>701-0015-00L</td>
<td>Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement</td>
<td>2</td>
<td>B. Vienni Baptista, C. E. Pohl, M. Stauffacher</td>
<td></td>
</tr>
</tbody>
</table>

The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) The specific challenges of inter- and transdisciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants’ research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

Literature

The following open access article builds a core element of the course:
available at (open access): http://www.ingentaconnect.com/content/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

Prerequisites / notice

Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

Taught competencies

551-0357-00L Cellular Matters: From Milestones to Open Questions
The number of participants is limited to 22 and will only take place with a minimum of 11 participants.

Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using in the subject: 551-0357-00.
In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

Abstract

In this course, the students will explore the quite new topic of biomolecular condensates.

Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Objective

In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

Content

In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that levered on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Lecture notes

The presentations will be made available after the lectures.

Literature

The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

Transferable Skills

Table:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<td>Only for doctoral students.</td>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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</tbody>
</table>

Abstract

The acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

<table>
<thead>
<tr>
<th>Code</th>
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<th>Credit</th>
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<tr>
<td>900-0103-DRL</td>
<td>Transferable Skills Course I (1-3 days, with Poster or Talk)</td>
<td></td>
<td>2</td>
<td>4S</td>
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<tr>
<td>900-0104-DRL</td>
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<tr>
<td>900-0105-DRL</td>
<td>Transferable Skills Course III (1-3 days, with Poster or Talk)</td>
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<tr>
<td>900-0106-DRL</td>
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<td>2</td>
<td>4S</td>
<td>Lecturers</td>
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Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0109-DRL  Transferable Skills Course I (min 4 days, with Poster or Talk)  W  3 credits  6S  Lecturers

Objectives:
- Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract:
- Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective:
- Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL  Transferable Skills Course II (min 4 days, with Poster or Talk)  W  3 credits  6S  Lecturers

Objectives:
- Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract:
- Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective:
- Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL  Transferable Skills Course III (min 4 days, with Poster or Talk)  W  3 credits  6S  Lecturers

Objectives:
- Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract:
- Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective:
- Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL  Participation in Commission I (min 1 year)  W  1 credit  2P  Lecturers

Objectives:
- Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract:
- Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective:
- Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL  Participation in Commission II (min 1 year)  W  1 credit  2P  Lecturers

Objectives:
- Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract:
- Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective:
- Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL  Member of Executive Board (min 1 year)  W  2 credits  4P  Lecturers

Objectives:
- Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract:
- Active participation in the presidium or executive board of a university group for at least 1 year.

Objective:
- Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UBZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

701-0703-00L  Environmental Ethics  W  2 credits  2V  A. Deplazes Zemp

Objectives:
- The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Content:
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Lecture notes:
- Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Prerequisites / notice
The procedure for accumulating CP will be explained at the start of term. We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

Abstract
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective
Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

Content
I. Introduction to Moral Reasoning
1. Ethics - the basics
1.1 What ethics is not... 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favorable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):

1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...).
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life.

Analytical Competencies

- Communication
- Cooperation and Teamwork
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

E. Bobst, N. Gruber, assessed

Concepts and Theories

- Decision-making
- Problem-solving

Social Competencies

- Analytical Competencies
- Defensive

Personal Competencies

- Analytical Competencies
- Problem-solving

E. Vayena, A. Blasimme, A. Ferretti, assessed

Analytical Competencies

- Analytical Competencies
- Problem-solving

G. Achermann assessed

Creative Thinking

- Creative Thinking
- Conceptual
- Theoretical

Concepts and Theories

- Analytical Competencies
- Decision-making
- Problem-solving

Objective

- Recognize how ethical issues relate to different accounts of technology and innovation.
- Distinguish different ethical approaches and argumentative strategies in applied ethics.
- Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
- Autonomously anticipate ethical issues.
- Propose and communicate solutions to ethical challenges and dilemmas.
- Work in a more ethically reflective way.
- Engage constructively in the public discourse relating to new technology impacts.
- Identify impacted stakeholders and who is ethically responsible.
- Evaluate the ethical dimensions of new technology uses.
- Explain relevant concepts in ethics.

Content

- The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics.
- The range of practical problems and issues in the domains of education, news media, society, social media, digital health and justice will be then considered. These six domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.
- The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.
- A range of practical problems and issues in the domains of education, news media, society, social media, digital health and justice will be then considered. These six domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

Objective

- This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.
- Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

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Objective

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Objective

- Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.
Content:

Part I on Moodle

The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II

The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice

For doctoral students only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II)

Taught competencies

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<th>Subject-specific Competencies</th>
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Integration into Scientific Community

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| 900-0151-DRL | Summer School II (1-3 days)                      | W    | 1 credit | 2K    | Lecturers |
| Abstract  | Participation in summer or winter schools with a maximum duration of 3 days. |
| Objective |                                      |

| 900-0152-DRL | Summer School III (1-3 days)                     | W    | 1 credit | 2K    | Lecturers |
| Abstract  | Participation in summer or winter schools with a maximum duration of 3 days. |
| Objective |                                      |

| 900-0153-DRL | Summer School I (1-3 days, with Poster or Talk) | W    | 2 credits | 4K    | Lecturers |
| Abstract  | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |
| Objective |                                      |

<p>| 900-0154-DRL | Summer School II (1-3 days, with Poster or Talk) | W    | 2 credits | 4K    | Lecturers |
| Abstract  | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |
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<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<td>Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.</td>
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Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Doctorate Biology - Key for Type

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

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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>636-0301-00L</td>
<td>Current Topics in Biosystems Science and Engineering</td>
<td>W</td>
<td>2 credits</td>
<td>1S</td>
<td>R. Platt, N. Beerenwinkel,</td>
</tr>
<tr>
<td></td>
<td>For doctoral students only. Master's students cannot receive credits for the seminar.</td>
<td></td>
<td></td>
<td></td>
<td>Y. Benenson, K. M. Borgwardt,</td>
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<td>P. S. Dittrich, M. Fussenegger,</td>
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<td>A. Hierlemann, D. Iber,</td>
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<td>M. H. Khammash, D. J. Müller,</td>
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<td>S. Panke, S. Reddy, T. Schroeder,</td>
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<td>J. Stelling, B. Treutlein</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This seminar will feature invited lectures about recent advances and developments in systems biology, including topics from biology, bioengineering, and computational biology.</td>
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<td></td>
<td>Objective</td>
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<td>To provide an overview of current systems biology research.</td>
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<td>Content</td>
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<td>The final list of topics will be available at <a href="https://www.bsse.ethz.ch/news-and-events/seminar-series.html">https://www.bsse.ethz.ch/news-and-events/seminar-series.html</a></td>
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<tr>
<td>636-0309-00L</td>
<td>Advances in Molecular Biotechnology</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>M. Fussenegger</td>
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<td></td>
<td>Abstract</td>
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<td>This seminar features the latest progress in molecular biotechnology, including topics from bioengineering, synthetic biology as well as gene- and cell-based therapies.</td>
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<td>Objective</td>
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<td>To provide an overview of current strategies to engineer mammalian cells.</td>
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<td>636-0009-00L</td>
<td>Evolutionary Dynamics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U+2A</td>
<td>N. Beerenwinkel</td>
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<td></td>
<td>Abstract</td>
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<td>Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.</td>
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<td>Objective</td>
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<td>The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.</td>
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<td>Content</td>
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<td>Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.</td>
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<td>Lecture notes</td>
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<td>Prerequisites / notice</td>
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<td>Prerequisites: Basic mathematics (linear algebra, calculus, probability)</td>
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<td>Taught competencies</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Self-direction and Self-management</td>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Critical Thinking</td>
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<tr>
<td>636-0104-00L</td>
<td>Biophysical Methods</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. J. Müller</td>
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<td></td>
<td>Abstract</td>
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<td>Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.</td>
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<td>Objective</td>
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<td>Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.</td>
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<td>Content</td>
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<td>The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.</td>
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<td>The biophysical methods to be taught will include:</td>
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<td>- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy</td>
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<td>- Super resolution optical microscopy: STED, PALM, STORM, other variations</td>
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<td>- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain</td>
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<td>- X-ray, electron and neutron diffraction</td>
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<td>- MRI Imaging</td>
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<td>- Scanning tunnelling microscopy and atomic force microscopy</td>
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<td>- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry</td>
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<td>- Surface plasmon resonance-based biosensors</td>
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<td>- Molecular pore-based sensors and sequencing devices</td>
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<td>- Mechanical molecular and cellular assembly devices</td>
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<td>- Optical and magnetic tweezers</td>
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<td>- CD spectroscopy</td>
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<td>- Optogenetics</td>
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<td>- Molecular dynamics simulations</td>
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<td>Lecture notes</td>
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<td>Hand out will be given to students at lecture.</td>
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The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with under the guidance of the teacher.
Abstract
This course provides an overview of modern concepts of bioengineering across different levels of complexity, from single molecules to systems, microscaled reactors to production environments, and across different fields of applications.

Objective
Students will be able to recognize major developments in bioengineering across different organisms and levels of complexity and be able to relate it to major technological and conceptual advances in the underlying sciences.

Content
Molecular and cellular engineering; Synthetic biology: Engineering strategies in biology; from single molecules to systems; downscaling bioengineering; Bioengineering in chemistry, pharmaceutical sciences, and diagnostics, personalized medicine.

Lecture notes
Handouts during class

Literature
Will be announced during the course

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Critical Thinking

Method-specific Competencies
- Analytical Competencies
- Communication

Social Competencies
- Communication

Personal Competencies
- Critical Thinking

636-0103-00L Microtechnology

W 4 credits 3G

A. Hierlemann

Abstract
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and -systems and all related microfabrication processes.

Objective
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.

Content
- Fundamentals of semiconductors and band model
- Fundamentals of devices; transistor and diode.
- Silicon processing and fabrication steps
- Silicon crystal structure and manufacturing
- Thermal oxidation
- Doping via diffusion and ion implantation
- Photolithography
- Thin film deposition; dielectrics and metals
- Wet etching & bulk micromachining
- Dry etching & surface micromachining
- Microtechnological processing and fabrication sequence
- Optional: Packaging

Lecture notes
Handouts in English

Literature

Prerequisites / notice
Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

The information on the web can be updated until the beginning of the semester.

Taught competencies
- Concepts and Theories
- Techniques and Technologies
- Critical Thinking

636-0105-00L Introduction to Biological Computers

W 4 credits 3G

Y. Benenson

Abstract
Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanotechnology and synthetic biology.

Objective
The course has the following objectives:

* Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms
* Introduce basic theories of computation
* Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include
- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly

* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations
* Foster creativity, research and communication skills through semester-long "Design challenge" assignment in the broad field of biological computing and biological circuit engineering.
Lecture 1. Introduction: what is molecular computation (part I)?

* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines

1st hour

* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour

* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation

* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4. Classical DNA computing

* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly

* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes

* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits

* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I

* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II

* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I

* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II

* RNAI logic circuits
* RNAI-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits

* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics

* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
The course is a mix of lectures and different exercise formats. Notes will be provided in the forms of handouts. Lecture notes will be available online.

**Literature**

As a way of general introduction, the following two review papers could be useful:


Basic knowledge of molecular biology is assumed.

**Prerequisites / notice**

- Students of this course know and can evaluate modern methods of microbial biotechnology and enzyme technology and understand their relation to modern applications of microbial biotechnology.
- Students of this course know and can evaluate modern methods of microbial biotechnology and enzyme technology and understand their relation to modern applications of microbial biotechnology.
- The course will cover in its main part selected fundamental and advanced topics and methodologies in microbial molecular biotechnology. Major topics include I) Microbial physiology of microbes (prokaryotes and selected fungi), II) Applications of Microbial Biotechnology, III) Enzymes - advanced kinetics and engineering, IV) Principles of in vivo directed evolution, V) System approaches to cell engineering/metabolic engineering, and VI) Trends in Microbial Biotechnology. The course is a mix of lectures and different exercise formats.
- Notes will be provided in the forms of handouts.
- The course will use selected parts of textbooks and then original scientific publications and reviews.

**Taught competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication, Cooperation and Teamwork
- Personal Competencies: Self-direction and Self-management

**Lecture notes**

- Lecture 14: Design challenge presentation
- Lecture notes will be available online

**2022 Autumn Semester**

**Lab 636-0107-00L Microbial Biotechnology**

- **Objective**: To familiarise the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.
- **Content**: Biotechnological and Biotechnological engineering will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. Lecture notes will be available online.

**Lab 636-0108-00L Biological Engineering and Biotechnology**

- **Objective**: To familiarise the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.
- **Content**: Biotechnological and Biotechnological engineering will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. Lecture notes will be available online.

**Lab 636-0550-00L Biomolecular Nanotechnology**

- **Objective**: To familiarise the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.
- **Content**: Biotechnological and Biotechnological engineering will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. Lecture notes will be available online.

**Lab 636-0109-00L Stem Cells: Biology and Therapeutic Manipulation**

- **Objective**: Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.
Content

We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

Taught competencies

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636-0118-00L Introduction to Dynamical Systems with Applications

Objective

The goal of this course is to introduce the student to dynamical systems and to develop a solid understanding of their fundamental properties. The theory will be developed systematically, focusing on analytical methods for low dimensional systems, geometric intuition, and application examples from biology. Computer simulations using matlab will be used to demonstrate various concepts.

Content

A dynamical view of the world; the importance of nonlinearity; solutions of differential equations; solving equations on the computer; the phase plane; fixed points and stability; linear stability analysis; classifications of linear systems; Liapunov functions and nonlinear stability; cycles and oscillations; bifurcations and bifurcation diagrams. Many biological examples will be used through the course to demonstrate the concepts.

Lecture notes

Will be provided as needed.

Literature


Prerequisites / notice

Prerequisites: Calculus; a first course in differential equations; basic linear algebra (eigenvalues and eigenvectors), Matlab programming.

636-0123-00L Problem-Based Approach to Spatial Biology

Objective

The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will obtain the necessary tools to independently identify open research problems in various areas of spatial biology, to address these problems with suitable experimental strategies, and to formulate their approach in a research proposal.

Content

We will use a problem-based approach to explore the way in which single cells collaborate within tissues to achieve their common functions. A thorough comprehension of these tissue components is crucial for advancing our knowledge of normal homeostasis and pathophysiology; disrupted cellular interactions can lead to decreased tissue function or even carcinogenesis.

The project work will be conducted in small groups in guidance of tutors. Each group will focus on a different topic in spatial biology and will review the corresponding literature. They will identify open problems of interest in this area and will summarize their findings in a short, written review. The students will then develop an appropriate experimental strategy to address a question of interest and write a research proposal that features their approach. The final stage of the project work enable the students to practice the presentation of their research proposals and critical evaluation.

Literature

Will be provided during the course.

Prerequisites / notice

This course requires independent group work.

636-0119-00L Introduction to Statistics and R

Objective

To acquire the statistical understanding to design an appropriate analysis and the practical skills to implement the analysis in R and present the results.

Content

Data analysis is fundamental for arriving at scientific conclusions and testing different hypotheses. This course offers a hands-on introduction to statistical analyses including: exploratory data analysis, testing differences in populations, p-values, power calculations, multiple testing, confounding, linear regression, maximum likelihood, model selection, and logistic regression; along with the fundamentals of R programming including markdown and data handling with the tidyverse.

Lecture notes

Lecture slides will be available

Prerequisites / notice

Access to Rstudio with some markdown and tidyverse packages installed.

636-0017-00L Computational Biology

Objective

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.
Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics
Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their applications both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Literature
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Abstract
Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content
Biological data analysis has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label “Systems Biology”, focuses on how networks, which are more than the mere sum of their parts’ properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes
http://www.csb.ethz.ch/education/lectures.html

Literature

636-0007-00L
Computational Systems Biology

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<tr>
<th>W</th>
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<td>J. Stelling</td>
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636-0101-00L
Systems Genomics

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<th>W</th>
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<td>N. Beerenwinkel, C. Beisel, S. Reddy</td>
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Abstract
This lecture course is an introduction to Systems Genomics. It addresses how fundamental questions in biological systems are studied and how the resulting data is statistically analyzed in order to derive predictive mathematical models. The focus is on viewing biology from a genomic perspective, which requires high-throughput experimental methods (e.g., RNA-seq, genome-scale screening, single-cell sequencing). Students will learn fundamental questions driving the field of Systems Genomics. They will also be introduced to traditional and advanced state-of-the-art technologies (e.g., CRISPR-Cas9 screening, droplet-microfluidic sequencing, cellular genetic barcoding) that are used to obtain quantitative data in Systems Genomics. They will learn how to use these data to develop mathematical models and efficient statistical inference algorithms to recognize patterns, molecular interrelationships, and systems behavior. Finally, students will gain a perspective of how Systems Genomics can be used for applied biological sciences (e.g., drug discovery and screening, bio-production, cell line engineering, biomarker discovery, and diagnostics).

Objective
The goal of this course is to learn how a detailed quantitative description of genome biology can be employed for a better understanding of molecular and cellular processes and function. Students will learn fundamental questions driving the field of Systems Genomics. They will also be introduced to traditional and advanced state-of-the-art technologies (e.g., CRISPR-Cas9 screening, droplet-microfluidic sequencing, cellular genetic barcoding) that are used to obtain quantitative data in Systems Genomics. They will learn how to use these data to develop mathematical models and efficient statistical inference algorithms to recognize patterns, molecular interrelationships, and systems behavior. Finally, students will gain a perspective of how Systems Genomics can be used for applied biological sciences (e.g., drug discovery and screening, bio-production, cell line engineering, biomarker discovery, and diagnostics).

Content
Lectures in Systems Genomics will alternate between lectures on (i) biological questions, experimental technologies, and applications, and (ii) statistical data analysis and mathematical modeling. Selected complex biological systems and the respective experimental tools for a quantitative analysis will be presented. Some specific examples are the use of RNA-sequencing to do quantitative gene expression profiling, CRISPR-Cas9 genome scale screening to identify genes responsible for drug resistance, single-cell measurements to identify novel cellular phenotypes, and genetic barcoding of cells to dissect development and lineage differentiation.

Main Topics:
- Next-generation sequencing
- Transcriptomics
- Biological network analysis
- Functional and perturbation genomics
- Single-cell biology and analysis
- Genomic profiling of the immune system
- Genomic profiling of cancer
- Evolutionary genomics
- Genome-wide association studies

Selected genomics datasets will be analyzed by students in the tutorials using the statistical programming language R and dedicated Bioconductor packages.
### Transferable Skills

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### Participation in Commission I (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**Objective**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

### Participation in Commission II (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**Objective**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

### Member of Executive Board (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Active participation in the presidium or executive board of a university group for at least 1 year.

**Objective**
Active participation in the presidium or executive board of a university group for at least 1 year.

### Ethics and Scientific Integrity for Doctoral Students
This course is interdisciplinary. If your department offers this course, please register there. The following departments offer this course in the fall semester 2022: D-BAUG, D-ERDW, MaP Doctoral School, D-USYS

Doctoral students from D-GESS will have the opportunity to register for a discipline-specific course in spring semester 2023.

**Abstract**
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

**Objective**
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

**Content**

**Prerequisites / notice**
For doctoral students only.

**Taught competencies**

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<th>Method-specific Competencies</th>
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> **Integration into Scientific Community**
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**Doctorate Biosystems Science and Engineering - Key for Type**

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**Key for Hours**

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**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
# Subject Specialisation

## Inorganic Chemistry

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<td>C. Copéret, H. Grützmacher, D. Günther, M. Kovalenko, T. Lippert, V. Mougel, P. Steinegger</td>
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## Organic Chemistry

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<td>Y. Barral, F. Allain, P. Arosio</td>
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<td>of day) via e-mail to <a href="mailto:bml@ethz.ch">bml@ethz.ch</a> using the</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 650 of 2345
address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

Abstract
In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials. In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverons, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Lecture notes
The presentations will be made available after the lectures. The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

Physical Chemistry

<table>
<thead>
<tr>
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<td>529-0460-00L</td>
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<td>E-</td>
<td>0</td>
<td>1S</td>
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<tr>
<td>529-0479-00L</td>
<td>Theoretical Chemistry, Molecular Spectroscopy and Dynamics</td>
<td>W</td>
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<td>F. Merkt, M. Reiher, J. Richardson, R. Signorell, H. J. Wörner</td>
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<td>Introduction to the Construction of Measurement Devices in Physical Chemistry</td>
<td>W</td>
<td>2</td>
<td>2P</td>
<td>F. Merkt</td>
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Objective
In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions. The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverons, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Content
In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Each week the lecture will consist of:
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2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Prerequisites / notice
The presentations will be made available after the lectures. The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

Lecture notes
The presentations will be made available after the lectures. The milestone papers will be provided in advance.

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Literature
The presentations will be made available after the lectures. The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.
Advanced High Resolution Molecular Spectroscopy

Objective

The students will understand how to use the tools needed to analyze simple highly resolved spectra. They will become familiar with experimental techniques in high resolution molecular spectroscopy and will understand how molecular spectroscopy can be applied to solve problems with respect to atmospheric pollutants and the detection of molecules in interstellar space.

Content

The students will learn how to record rotationally and rovibrationally resolved spectra in the THz and IR frequency range. For that purpose state-of-the-art solutions like synchrotrons, FELs and other THz sources will be discussed. In this context, the basics of Fourier transform infrared spectroscopy will be introduced. The analysis of such spectra will then be explained. Finally, applications of high resolution molecular spectroscopy in the field of atmospheric and interstellar chemistry will be discussed. The identification and the quantitative determination of atmospheric pollutants will be discussed in detail. In addition, the identification of interstellar molecules in the context of the origin of life will be reviewed. The question of the identification of the interstellar unidentified infrared bands and of the interstellar diffuse bands will also be addressed. Finally, high resolution molecular spectroscopy of chiral molecules in the context of molecular parity violation will be discussed.

Literature

Will be given in the lecture

Calculating Free Energy Differences from Molecular Simulation: Theory and Practical Applications

Abstract

Theoretical analysis as well as issues of practical implementation of state of the art free energy methods.

Objective

Recognition of the concepts that underlie the different approaches devised for the determination of free energies

Content

A wide variety of fundamental chemical quantities such as binding or equilibrium constants, solubilities, partition coefficients, and adsorption coefficients are related to the difference in free energy between particular (non)physical states of a system. A maze of computational techniques to calculate free energies is nowadays available that differ in efficiency and accuracy. However, most of them are rooted in a few basic ideas. In the lecture state of the art methods are discussed in light of these basic ideas.

Lecture notes

Handouts will be provided

Literature


Cellular Matters: From Milestones to Open Questions

The number of participants is limited to 22 and will only take place with a minimum of 11 participants. Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using the subject: 551-0357-00. In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

Abstract

In this course, the students will explore the quite new topic of biomolecular condensates.

Objective

Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biomolecular properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Content

In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

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Lecture notes

The presentations will be available after the lectures.

Literature

The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.
The presentations will be made available after the lectures.

Students are expected to attend all seminars in one academic year, and should register at the beginning of each seminar. Additionally they must deliver a two page written report at the end of the year describing the topics covered, main conclusions, and interrelationships between the different themes.

The ICB seminar series covers the umbrella of diverse research activities encompassed within the institute, including catalysis, functional materials, polymer engineering, separations, microfluidics, process design, and systems engineering. This series was founded with the aim of promoting cross-disciplinary scientific discourse and interaction with other distinguished groups working worldwide.

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The presentation will be made available after the lectures.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

### Polymer Science

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<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Yulikov, G. Jeschke</td>
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The course will provide the "polymer physics view" for the broad area of bio-polymers research. This will include simple and advanced concepts, forming the theoretical "language", critical overview of experimental methods, including the differences in characterization of synthetic and bio-polymers, concepts for modelling conformational ensembles of unstructured bio-polymers.

From the fundamental education point, this course will systematically overview the power of the thermodynamic description, and the interplay between the energy and the entropy for the phenomena that happen at the edge of near equivalence of the thermal energy and the inter-molecular interaction energy.

Due to complexity of the bio-molecular interactions, the most successful research approaches in the field of unstructured bio-polymers are based on a clever combination of several structural and spectroscopic methods.

Therefore, in this course, there will be a good opportunity to introduce the cross-validation analysis based on complimentary spectroscopic methods, to see examples from real research on different accuracy and different applicability ranges of experimental methods, and to discuss how very different spectroscopic data types can be combined to enhance the understanding of a bio-polymer system.
The objective of the course is to gain a global understanding of most of the important phases in the discovery and development of modern pharmaceuticals.

Thirteen two hour lectures for life-science PhD students and students of the Pharmaceutical Sciences Master, given by experts from the ETH, UZH, USZ and the pharmaceutical industry.

The lecture series takes place at the ETH Hönggerberg and covers a variety of major activities involved in drug discovery: selecting drug targets, technologies used in drug discovery, small, medium and large drugs, objectives of the medicinal chemist, assessing drug safety, principles of personalized medicine, designing clinical trials, how intellectual property is protected, as well as others.

The objective of the course is to gain a global understanding of most of the important phases in the discovery and development of modern synthetic and biological drugs, from the first activities to clinical trials. The lecture is intended for students that have an interest in the area and/or may consider a career working in drug discovery. This lecture course complements knowledge and experience gained in the research project performed by the PhD student.

The lecture series takes place at the ETH Hönggerberg and covers a variety of major activities involved in drug discovery: selecting drug targets, technologies used in drug discovery, small, medium and large drugs, objectives of the medicinal chemist, assessing drug safety, principles of personalized medicine, designing clinical trials, how intellectual property is protected, as well as others.

The lecture course complements knowledge and experience gained in the research project performed by the PhD student.

Additional Courses

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Pharmaceutical Sciences

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<td>0</td>
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<td>G. Schneider</td>
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Prerequisites / notice

To be distributed during the lecture.

To be uploaded into ILIAS.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 654 of 2345
Abstract
Students learn how to effectively retrieve, critically judge, analyze, and manage published scientific information – important skill sets in chemistry and life sciences where scientists need to deal with vast amounts of information. The course, using practical examples, also covers scientific writing, visualizations, science communication and state-of-the-art technologies such as text mining.

Objective
Students are made aware of the wide variety of information solutions that exist today for all kinds of research processes, get an independent understanding of how they are derived and learn how to critically judge their quality. They learn how scientific communication works today and on which concepts and principles it is based. They develop the ability to select appropriate, subject-specific databases or tools for a given specific scientific question based on a sound understanding on how a tool or database has been developed and maintained, thus building the personal capacity of doing research effectively and efficiently by integrating scientific information into the research process when needed. Students learn how to evaluate information solutions, to build suitable search strategies and to integrate them in their information workflows. Also, they learn how to effectively communicate their own scientific results using various distribution channels and to measure the impact of their outreach activities. Overall, they gain the ability to perform all steps of the research cycle in a time- and cost-efficient manner, from the research strategy up to writing a first paper and their Ph.D. thesis.

Content
The course has been primarily designed for Ph.D. students, also for the Life Science Zurich Graduate School, but is also open to Master students. In a series of 12 units, which always include practical examples (for some lectures a notebook is required), the use of scientific information is taught not in a database-centric view but corresponding to the steps through which scientific research is conducted – including the dissemination of scientific results. This is particularly interesting for students who are about to write-up their first paper or thesis.

Students will learn about the different types of information resources and tools, get an insight into the numerous databases and tools that exists and how those are built and maintained, enabling them to critically judge the value and trustworthiness of an information resource. Additionally, they will learn how to communicate their own scientific results properly, using also additional measures that are reflected by alternative metrics.

The following topics are covered in twelve modules:
1. & 2. The world of scientific publishing: basics, publishing models
3. Searching and retrieving scientific information using search engines and literature databases
4. Searching and retrieving scientific information using subject-specific databases in chemistry and materials science
5. Searching and retrieving scientific information using subject-specific databases in life sciences
6. Tools for analyzing scientific information
7. Tools for managing scientific information and sharing knowledge, including pipelining tools
8. Patents
9. Text (literature) mining
10. Visualizing molecules for lab reports, presentations, posters, and publications
11. Scientific writing, good design & good scientific practice
12. Communicating & analyzing the impact of (your) science

Lecture notes
The slide deck and supplementary materials will be made available in the teaching document repository (ILIAS) after each lecture.

Literature
Additional literature and reference are provided in the course material.

Taught competencies
Method-specific Competencies
Analytical Competencies
not assessed
Media and Digital Technologies
not assessed
Project Management
not assessed
Communication
not assessed
Critical Thinking
not assessed

► Transferable Skills

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Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Abstract

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Abstract

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

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Abstract
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0155-DRL: Summer School III (1-3 days, with Poster or Talk)
Only for doctoral students.

900-0156-DRL: Summer School I (min 4 days)
Only for doctoral students.

900-0157-DRL: Summer School II (min 4 days)
Only for doctoral students.

900-0158-DRL: Summer School III (min 4 days)
Only for doctoral students.

900-0159-DRL: Summer School I (min 4 days, with Poster or Talk)
Only for doctoral students.

900-0160-DRL: Summer School II (min 4 days, with Poster or Talk)
Only for doctoral students.

900-0161-DRL: Summer School III (min 4 days, with Poster or Talk)
Only for doctoral students.

900-0162-DRL: External Conference I (incl. Poster or Talk)
Only for doctoral students.
Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0163-DRL External Conference II (incl. Poster or Talk)  
Only for doctoral students.

Abstract Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

900-0164-DRL External Conference III (incl. Poster or Talk)  
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Doctorate Chemistry and Applied Biosciences - Key for Type

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<td>Eligible for credits</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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Key for Hours

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 659 of 2345
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

This class will allow the students to learn about the modern methods and ideas on heat and mass transfers in magmatology through classic

1S

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

Lecturers

Geophysical Fluid Dynamics and Numerical Modelling

1S

Transferable Skills Course I (1-3 days, with Poster or Talk)

Seminar II: Heat and Mass Transfers in Magmatology

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

Type

Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

Objective

Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

Content

Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1617-00L

Geophysical Fluid Dynamics and Numerical Modelling

E-

Seminar

2S

Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

Objective

Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

Content

Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1493-00L

Seminar I: Heat and Mass Transfers in Magmatology

W

1 credit

1S

O. Bachmann, C. Chelle-Michou, T. Keller

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

Type

Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

Objective

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Content

Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1493-00L

Seminar II: Heat and Mass Transfers in Magmatology

W

1 credit

1S

O. Bachmann, C. Chelle-Michou, T. Keller

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

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Content

Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1493-00L

Seminar III: Heat and Mass Transfers in Magmatology

W

1 credit

1S

O. Bachmann, C. Chelle-Michou, T. Keller

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

Type

Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

Objective

Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

Content

Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1493-00L

Seminar IV: Heat and Mass Transfers in Magmatology

W

1 credit

1S

O. Bachmann, C. Chelle-Michou, T. Keller

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

Type

Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

Objective

Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

Content

Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1493-00L

Seminar V: Heat and Mass Transfers in Magmatology

W

1 credit

1S

O. Bachmann, C. Chelle-Michou, T. Keller

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration

Type

Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

Objective

Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

Content

Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.
900-0104-DRL  Transferable Skills Course II (1-3 days, with Poster or Talk)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0105-DRL  Transferable Skills Course III (1-3 days, with Poster or Talk)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0106-DRL  Transferable Skills Course I (min 4 days)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0107-DRL  Transferable Skills Course II (min 4 days)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0108-DRL  Transferable Skills Course III (min 4 days)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0109-DRL  Transferable Skills Course I (min 4 days, with Poster or Talk)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL  Transferable Skills Course II (min 4 days, with Poster or Talk)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL  Transferable Skills Course III (min 4 days, with Poster or Talk)  
Only for doctoral students.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year) W 1 credit 2P Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) W 2 credits 4P Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

651-6001-00L Ethics and Scientific Integrity for Doctoral Students of D-ERDW W+ 1 credit 2S T. I. Eglinton, H. Stoll

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content
Part I
The self-paced e-learning course consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For Doctoral Students of D-ERDW only

Taught competencies
Subject-specific Competencies
- Concepts and Theories
Method-specific Competencies
- Decision-making
Personal Competencies
- Critical Thinking
- Integrity and Work Ethics

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

Number Title Type ECTS Hours Lecturers
900-0150-DRL Summer School I (1-3 days) W 1 credit 2K Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer
<table>
<thead>
<tr>
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<th>Credits</th>
<th>Lecturers</th>
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<td>Summer School II (1-3 days)</td>
<td>W 1</td>
<td>2K Lecturers</td>
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<tr>
<td>900-0152-DRL</td>
<td>Summer School III (1-3 days)</td>
<td>W 1</td>
<td>2K Lecturers</td>
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<tr>
<td>900-0153-DRL</td>
<td>Summer School I (1-3 days, with Poster or Talk)</td>
<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>900-0154-DRL</td>
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<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>900-0155-DRL</td>
<td>Summer School III (1-3 days, with Poster or Talk)</td>
<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>900-0156-DRL</td>
<td>Summer School I (min 4 days)</td>
<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>900-0157-DRL</td>
<td>Summer School II (min 4 days)</td>
<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>900-0158-DRL</td>
<td>Summer School III (min 4 days)</td>
<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>900-0159-DRL</td>
<td>Summer School I (min 4 days, with Poster or Talk)</td>
<td>W 3</td>
<td>6K Lecturers</td>
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</table>
Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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<td>900-0160-DRL</td>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>900-0161-DRL</td>
<td>Summer School III (min 4 days, with Poster or Talk)</td>
<td>Only for doctoral students.</td>
<td>3 credits</td>
<td>6K</td>
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<tr>
<td>900-0162-DRL</td>
<td>External Conference I (incl. Poster or Talk)</td>
<td>Only for doctoral students.</td>
<td>1 credit</td>
<td>2K</td>
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<td>Abstract</td>
<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Objective</td>
<td>Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.</td>
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<td>900-0163-DRL</td>
<td>External Conference II (incl. Poster or Talk)</td>
<td>Only for doctoral students.</td>
<td>1 credit</td>
<td>2K</td>
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**Doctorate Earth Sciences - Key for Type**

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

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

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The students shall obtain the following competence:

Creative Thinking

assessed

The aim of this colloquium is that the presenters receive feedback on their research at an important stage (a stage at which significant changes of direction, methodology, etc., may still be undertaken) in the PhD process.

Content

Presentation of doctoral research.

Lecture notes

Distributed electronically.

Literature

Distributed electronically.

Prerequisites / notice

Dates: See http://www.cis.ethz.ch/education/index

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PhD Colloquium in Development Economics

Does not take place this semester.

PhD students working in empirical development economics will present their ongoing work, with a particular focus on the methods (to be) used and challenges faced. Participants are expected to read the drafts/papers/presentations beforehand and give constructive feedback to the PhD student presenting.

Objective

PhD students learn how to present and discuss their own research questions, methods, results and problems. PhD students get familiar with the challenges of empirical economics research in low income countries.

Prerequisites / notice

This is a two days course.

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Law for Entrepreneurs

Number of participants limited to 100

Abstract

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective

The students shall obtain the following competence:
- They shall acquire a basic knowledge about the legal environment of entrepreneurs.
- They shall be able to recognize and evaluate legal issues involved in setting up and managing an enterprise.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes

A comprehensive script will be made available online on the moodle platform.

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Workshop & Lecture Series on the Law & Economics of Innovation

This series is a joint project by ETH Zurich and the Universities of St. Gallen and Zurich. It provides an overview of interdisciplinary research on intellectual property, innovation, antitrust, privacy & technology policy. Scholars from law, economics, management and related fields present their current research. All speakers are internationally well-known experts from Europe, the U.S. & beyond.

Objective

After the workshop and lecture series, participants should be acquainted with interdisciplinary approaches towards intellectual property, innovation, antitrust, privacy and technology policy research. They should also have an overview of current topics of international research in these areas.

Content

The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.

Lecture notes

Papers discussed in the workshop and lecture series are posted in advance on the course web page.

Literature

Suzanne Scotchmer, Innovation and Incentives, 2004
Bronwyn Hall / Nathan Rosenberg (eds.), Handbook of the Economics of Innovation, 2 volumes, Amsterdam 2010
Bronwyn Hall / Dietmar Harhoff, Recent Research on the Economics of Patents, 2011

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Intellectual Property: Introduction

Particularly suitable for students of D-CHAB, D-INFK, D-ITET, D-MAVT, D-MATL, D-MTEC

Abstract

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

Number of participants limited to 100

Notices

Does not take place this semester.

Change of direction, methodology, etc., may still be undertaken) in the PhD process.
Objective
The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector
Particularly suitable for students of D-BAUG, D-BIOL, D-BSSE, D-CHAB, D-ITET, D-MAVT

Abstract
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Objective
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The lecture will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice
The lecture addresses students in the fields of engineering, science and other related technical fields.

Subject-specific Competencies
- Concepts and Theories
- Problem-solving
- Critical Thinking
- Self-awareness and Self-reflection

Method-specific Competencies
- assessed

Personal Competencies
- assessed

851-0252-04L Behavioral Studies Colloquium

Abstract
This colloquium offers an opportunity to discuss recent and ongoing research and scientific ideas in the behavioral sciences, both at the micro- and macro-levels of cognitive, behavioral and social science.

The colloquium features invited presentations from internal and external researchers as well as presentations of doctoral students close to submitting their dissertation research plan.

Objective
Participants are informed about recent and ongoing research in different branches of the behavioral sciences. Presenting doctoral students obtain feedback on their dissertation research plan.

Content
This colloquium offers an opportunity to discuss recent and ongoing research and scientific ideas in the behavioral sciences, both at the micro- and macro-levels of cognitive, behavioral and social science. It covers a broad range of areas, including theoretical as well as empirical research in social psychology, research on higher education, sociology, modeling and simulation in sociology, decision theory and behavioral game theory, economics, research on learning and instruction, cognitive psychology and cognitive science.

The colloquium features invited presentations from internal and external researchers as well as presentations of doctoral students close to submitting their dissertation research plan.

Prerequisites / notice
https://cog.ethz.ch/teaching/behavioral-studies-colloquium.html

851-0252-01L Human-Computer Interaction: Cognition and Usability
Number of participants limited to 35.

Abstract
This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.

Objective
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

851-0252-05L Research Seminar Cognitive Science

Abstract
The colloquium provides a forum for researchers and graduate students in cognitive science to present/discuss their ongoing projects as well as jointly discuss current publications in cognitive science and related fields. A subset of the sessions will include invited external visitors presenting their research. Participants of this colloquium are expected to be involved in active research group.

Objective
Graduate student train and improve their presentation skills based on their own project ideas, all participants stay informed on current trends in the field and have the opportunity for networking with invited scholars.
Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy sector necessary. This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g. sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.

Further literature will be recommended in the lectures.

**Literature**

- Manifesto of Computational Social Science
  - https://science.sciencemag.org/content/323/5915/721.full.pdf
- Social Self-Organisation
- How simple rules determine pedestrian behaviour and crowd disasters
  - https://www.pnas.org/content/108/17/6884.short
- Peer review and competition in the Art Exhibition Game
  - https://www.pnas.org/content/113/30/6414.short
- Generalized network dismantling
  - https://www.pnas.org/content/116/14/6554.short
- Computational Social Science: Obstacles and Opportunities
  - https://science.sciencemag.org/content/369/6507/1060?rss=1
- Bit by Bit: Social Research in the Digital Age
  - https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFXX2/

Further literature will be recommended in the lectures.
Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

851-0105-00L
Background Knowledge Arabic World

W 2 credits 2V U. Göksen

Abstract
This lecture will discuss important topics of the Arab culture involving concepts relating to history, the role of literature, sciences and religion, concepts of 'the West', meaning of education, understanding of culture as well as current concepts and discourses relevant at the sociocultural level.

Objective
Teaching about epistemic contents relating to the Arabic world that constitute modern Arabs' self understanding and are relevant for adequate behavior in practically dealing with the Arabic world. What basic knowledge about 'their' culture are Arabs taught? What educational goals are pursued? What is the relationship they build with the West?

The topics that are discussed on the basis of a scientifically critical approach are concepts and understandings of history, the role of literature, sciences and religion, concepts of the West and relationship with the West, the role of education, understanding of culture and cultural refinement, current concepts and discourses relevant at the sociocultural level.

851-0252-10L
Project in Behavioural Finance

W 3 credits 2S S. Andraszewicz, C. Hölscher, A. C. Roberts

Abstract
In this seminar, students will study cognitive processes, behaviour and the underlying biological response to financial decisions. Research methods such as asset market experiments, lottery games, risk preference assessment, psychometrics, neuroimaging and psychophysiology of decision processes will be discussed. Financial bubbles and crashes will be the core interest.

Objective
This course has four main goals:
1) To learn about the most important topics within Behavioural Finance
2) To learn how to conduct behavioural studies, design experiments, plan data collection and experimental tasks
3) To learn about causes of market crashes, factors that influence them, traders' behaviour before, during and after financial crises
4) To investigate a topic of interest, related to behaviour of traders during market crashes.

Additionally, the course gives to the students the opportunity to practice oral presentations, communication skills, report writing and critical thinking.

Content
The course provides an overview of the most important topics in Behavioural Finance. First part of the course involves reading scientific articles, which will be discussed during the seminar. Therefore, attendance is required to pass the course. Each week, a student volunteer will present a paper and the presentation will be followed by a discussion. After obtaining sufficient knowledge of the field, students will select a topic for a behavioural study of their own. The final assignment consists of preparing and conducting a small behavioural study/experiment, analysing the data and presenting the project in the final meeting of the class. Each student will write a scientific report of their study.

701-0015-00L
Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement

W 2 credits 2S B. Vienni Baptista, C. E. Pohl, M. Stauffacher

Abstract
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

Objective
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

Content
The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) Specific challenges of inter- and transdisciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants' research projects more societally relevant

Literature
Literature will be made available to the participants.

Further, this collection of tools will be used
https://naturalisciences.ch/topics/co-producing_knowledge

Prerequisites / notice
Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 26 November, 23 November

Taught competencies
Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Problem-solving
Social Competencies
Cooperation and Teamwork
Sensitivity to Diversity
Personal Competencies
Critical Thinking
Self-awareness and Self-reflection

851-0252-13L
Network Modeling

W 3 credits 2V C. Stadtfeld, to be announced

Abstract
Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective
Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and tests those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and develop an understanding of how those can be fit to empirical data. This will enable students to independently address research questions from various social science fields.
The following topics will be covered:

- Introduction to network models and their applications

- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models

- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)

- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)
  * Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes

Slides and lecture notes are distributed via the associated course moodle.

Literature


Prerequisites / notice

Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>851-0252-15L</td>
<td>Network Analysis</td>
<td>3</td>
<td>2V</td>
<td>U. Brandes</td>
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<tr>
<td>851-0742-00L</td>
<td>Contract Design I</td>
<td>3</td>
<td>2V</td>
<td>A. Stremitzer</td>
</tr>
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Abstract

Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Objective

Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

Content

The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

* Empirical Research and Network Data
* Macro and Micro Structure
* Centrality
* Roles
* Cohesion

Lecture notes

Lecture notes are distributed via the associated course moodle.

Literature


Abstract

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.
Objective

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Lecture notes

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Prerequisites / notice

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (sergevonsteiger@gess.ethz.ch).

Taught competencies

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

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Negotiation assessed

Personal Competencies
Creative Thinking assessed

851-0732-06L Law & Tech

Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/s/o7dtH9K5i9GJ) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

Abstract

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective

The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content

The planned course outline is below
1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

851-0101-86L Complex Social Systems: Modeling Agents, Learning, and Games

Number of participants limited to 100.

Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract

This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Content

Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lecture notes

The lecture slides will be presented on the course web page after each lecture.
Communication

Network science as a paradigm is entering domains from engineering to the humanities but application is tricky.

Further literature will be recommended in the lectures.

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

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The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".
The study of consciousness involves scholars from diverse fields, such as psychology, neuroscience, cognitive science, philosophy, linguistics, computer science, medicine, religious studies, anthropology, as well as literature and art studies. While the study of consciousness is presented mainly from the point of view of psychology in this course, additional interdisciplinary viewpoints are also integrated.

Psychological consciousness studies involve research on levels and states of consciousness. Psychologically researched levels of consciousness are the conscious, preconscious, unconscious/subconscious, and nonconscious levels of mental processing. Psychological research on states of consciousness – which is the main focus of this course – takes waking consciousness as the most common state (ordinary state of consciousness, OSC), using it as a baseline against which altered states of consciousness (ASCs) are compared. Some of the most prominently or promising researched ASCs in psychology will be introduced in this course and include sleeping/dreaming, hypnosis, meditation, sensory deprivation (e.g., floating tank), rhythm-induced trance, as well as ASCs induced by psychoactive drugs (classic psychedelics, dissociative anesthetics, empathogens). Furthermore, it will also be shown how a growing number of health and clinical studies investigate the therapeutic potential of being temporarily in an ASC. Finally, in this course, two mental phenomena that are also highly relevant for the scientific mind – insight and flow – are also introduced from a consciousness-studies perspective.

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**851-0745-00L**

**Building a Robot Judge: Data Science for Decision-Making (Course Project)**

*This is the optional course project for "Building a Robot Judge: Data Science for the Law."*

Please register only if attending the lecture course or with consent of the instructor.

Some programming experience in Python is required, and some experience with text mining is highly recommended.

**Abstract**

Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

**Objective**

In a semester paper, students (individually or in groups) will conceive and implement their own research project applying natural language processing in a robot judge. Some programming experience in Python is required, and some experience with NLP is highly recommended.

**Content**

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a legal professional. This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks. Review tools and resources currently available that facilitate resolutions and ethical practice work in a more ethically reflective way.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, news media, society, social media, digital health and justice will be then considered. These six domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explain-ability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

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**851-0745-00L**

**Building a Robot Judge: Data Science for Decision-Making**

Particularly suitable for students of D-INFK, D-ITET, D-MTEC

**Abstract**

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

**Objective**

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

**Content**

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

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**851-0742-01L**

**Contract Design II**

Does not take place this semester.

This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).

---
**Abstract**

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

**Objective**

There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer’s Teaching Assistant Diego Caldera (diegocalberto.caldaraherrera@uzh.ch).

**Prerequisites / notice**

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

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**851-0197-00L Medieval and Early Modern Science and Philosophy**

**W**

3 credits

2V

to be announced

**Abstract**

The course analyses the evolution of the relation between science and philosophy during the Middle Age and the Early Modern Period.

**Objective**

The course aims are:
- to introduce students to the philosophical dimension of science;
- to develop a critical understanding of scientific notions;
- to acquire skills in order to read and comment on scientific texts written in the past ages.

**Content**

The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine between science and philosophy and the shift from medieval times to the early modern world.

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**851-0255-00L Introduction to Methods in Learning Sciences II**

**W**

2 credits

2S

M. Kapur

**Abstract**

The course aims at providing students with practical knowledge and skill of processing, interpreting and analyzing empirical educational data, including different lenses through which to view the nature of inquiry in the field, research design, and an overview of quantitative, qualitative and mixed methods research.

**Objective**

The course will be centered around exploring methodological perspectives by focusing on conceptual aspects of datasets and experiments in the Learning Sciences. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, performing data analysis, finding patterns in data and linking them to educational theory).

**Content**

The course has the following components: a) advanced statistical methods (e.g., mediation and moderation), b) advanced qualitative methods (e.g., interaction analysis), c) computational methods (e.g., prediction and structured discovery with educational data).

**Prerequisites / notice**

Participation in the introductory version of this course (851-0252-14L Introduction to Methods in Learning Sciences) should be helpful, but not necessary. The class will be designed to allow students with strong STEM backgrounds to catch up and fully participate.

---

**851-0256-00L Future Learning Initiative Colloquium**

**W**

0.5 credits

1K

M. Kapur

**Abstract**

This colloquium offers an opportunity for students to present and discuss their ongoing projects broadly related to the science of learning. The colloquium also welcomes students from other disciplines who are interested in understanding the nature of formal and informal learning as a complex phenomenon across multiple, interacting levels: neural, cognitive, embodied, social, and cultural.

**Objective**

Students will have opportunities to develop their own ideas in the field of learning sciences and to communicate their ideas in oral presentations and in written papers. To achieve credit for the course, students are expected to either present their own research or provide scholarly feedback on the presented research.

**Content**

This colloquium offers an opportunity for students to discuss their ongoing research and scientific ideas in the learning sciences. This includes research aimed at understanding the nature of formal and informal learning as a complex phenomenon across multiple, interacting levels: neural, cognitive, embodied, social, and cultural. The colloquium also offers an opportunity for students from other disciplines to discuss their ideas in so far as they have some relation to the Future Learning Initiative at ETH or to the science of learning more broadly. Existing Future Learning Initiative projects include productive failure and preparation for future learning, neural basis of learning, mixed reality environments, physical spaces and learning, interdisciplinarity in life sciences education, embodied learning and gaming, abstract mathematical cognition, learning of ethics, project-based learning, and assessment validity.

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**851-0624-00L ETH4D PhD Seminar: Research for Development**

**W**

1 credit

1K

I. Günther, A. Rom, E. Tilley

**Abstract**

Doctoral candidates from all ETH departments, whose research is related to global sustainable development issues, and conducting research in low- or middle-income countries are invited to give a presentation about their on-going work and discuss their doctoral project with a diverse group of researchers.

**Objective**

Doctoral students are able to present their doctoral project to an interdisciplinary audience and to respond to questions within a wider global sustainable development context.

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**851-0252-14L Introduction to Methods in Learning Sciences I**

**W**

2 credits

1S

M. Kapur, T. Sinha

**Abstract**

The course registration targeted primarily at students enrolled in the ETH-EPFL joint doctoral program in the Learning Sciences. Language of performance assessment will be English.
Current topics of practical philosophy are discussed on the basis of texts and lectures. The field of learning sciences concerns two interrelated questions: How do people learn? How can we support learning? This course provides an overview of major theoretical perspectives that attempt to describe how learning works, and serves as an introduction to interpreting education as a means of designing learning environments. Students are expected to become competent in understanding cognitive, embodied, and social perspectives on learning and learning environment design.

The course is centered around exploring methodological perspectives by focusing on conceptual aspects of datasets and experiments. The lectures provide an overview of the foundations of cognitive science and investigate processes of human cognition, especially with respect to knowledge acquisition, knowledge representation and usage in information processing tasks. Cognitive Science views human cognition as information processing and provides an inter-disciplinary integration of approaches from cognitive psychology, informatics (e.g., artificial intelligence), neuroscience and anthropology among others. Cognitive Science provides an overview of basic mechanisms of human information processing and various application domains. A focus will be on matters of knowledge acquisition, representation and usage in humans and machines. Models of human perception, reasoning, memory and learning are presented and students will learn about experimental methods of investigating and understanding human cognitive processes and representation structures.

The course is structured thematically, adopts a multidisciplinary approach, and uses academic texts as well as concrete examples. It considers the continuities and changes in terms of scientific epistemologies and practices regarding the body. In doing so, debated contemporary issues such as assisted reproductive technologies and wearable systems of surveillance of the worker fatigue in the workplace are discussed. The ‘long durée’ approach of the course allows to consider the continuities and changes in terms of scientific epistemologies and practices regarding the body. In doing so, debated contemporary issues such as assisted reproductive technologies and wearable systems of surveillance of the worker fatigue in the workplace are discussed. The course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.
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<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>not assessed</td>
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### 851-0101-90L

**Concepts and Theories**

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<th>W</th>
<th>A. Kilcher</th>
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<td>3 credits</td>
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</table>

**Objective**

The meaning of the "beautiful" seems hard to pin down. Yet intersubjective and objective criteria of the beautiful nevertheless exist. The foundation of aesthetics as a "science" of the beautiful based on sensuous experience temporarily suspended this tension. Since modernity, the question of the beautiful has been ever more open. We shall approach this question theoretically and historically.

**Abstract**

The meaning of the "beautiful" seems hard to define. At first glance, it rather constitutes a merely subjective sensation. Yet, on the other hand, intersubjective, collective and cultural ideas, or even objective criteria of the beautiful exist. Since antiquity, this irresolvable tension has characterized the discourse on the beautiful in the realms of art and philosophy. With the foundation of "aesthetics" in the 18th century, however, this debate was significantly altered. This new "science" aimed at a scientific investigation of the beautiful by situating sensuous impression above logic. While art had hitherto understood as a learnable technique, it now appears as a sensuous and therefore subjective realization. The rejection of this optimism marks the turn to modernity that defined itself through a notion of art transcending the beautiful. Ever since, the question as to the meaning of the beautiful has been continuously open for debate. In the course of this seminar, we shall approach this question from a historical as well as theoretical perspective.

### 851-0061-00L

**History of Knowledge in the Making (University of Zurich)**

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<th>W</th>
<th>2 credits</th>
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<th>University lecturers</th>
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**Number of participants limited to 15.**

**Abstract**

This doctoral seminar provides a platform for PhD projects in the history of knowledge.

**Objective**

We focus on the specific forms, circulations, and practices of knowledge, its discursive, cultural, and social, moreover its scientific, technological, media, and infrastructural, as well as its legal, economic, and political conditions and effects in global and transnational perspectives. Based on the participants' research projects, the seminar introduces the methods, relevant literature and current issues in the history of knowledge.

**Prerequisites / notice**

Languages: German and English

### 862-0004-15L

**Research Colloquium Philosophy for Master Students and PhD (HS 2022)**

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<tr>
<th>W</th>
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<th>R. Wagner, M. Hampe, N. Mazouz, L. Wingert</th>
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</thead>
</table>

**Abstract**

For MAGPW and PhD students of D-GESS only.

**Objective**

Ph.D. students, post docs, members of staff, and senior colleagues from other philosophy departments will report on their work in progress. Furthermore, promising new philosophical articles and parts of new philosophical books will be studied.

### 862-0078-13L

**Research Colloquium. Extra-European History and Global History (HS 2022)**

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<th>H. Fischer-Tiné, M. Dusinberre</th>
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</thead>
</table>

**Objective**

Ideas and arguments dealing with systematic problems especially in epistemology, ethics, political philosophy, and the philosophy of mind will be scrutinized and elaborated.

### 862-0088-11L

**Research Colloquium Science Studies (HS 2022)**

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<th>W</th>
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<th>M. Hagner</th>
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**Objective**

Lectures may be held either in English or German. Students receive 2 credit points for submitting a brief, written commentary on one of the presented topics (approx. 5 pages).

### 862-0089-11L

**Advanced Colloquium in Literary Studies (HS 2022)**

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<th>A. Kilcher</th>
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**Objective**

The colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.

### 851-0101-31L

**The Rise of an Asian Giant: Introduction to the History of Modern India (c. 1600-2000)**

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<tr>
<th>W</th>
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<th>H. Fischer-Tiné</th>
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</table>

**Abstract**

This lecture offers a survey of the historical trajectories taken by the countries of the Indian subcontinent from the 17th century to the turn of the 21st century. The thematic foci include, but are not limited, to an examination of the question whether or not there was a pre-European South Asian modernity.
Objective
Through this course students are acquainted with the history of one of the most important world regions. The objective is not only to introduce participants to a richly diverse civilization, they are also encouraged to look at interrelations and make comparisons with the West. Through this approach their knowledge of European history is contextualised in a global framework while simultaneously their intercultural sensitivity is being trained.

851-0184-00L Pluralist Philosophy of Mathematics

Abstract
This course will follow Michèle Friend's book "pluralism in mathematics". It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.

Objective
The goal is to introduce students to current mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.

Content
The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralist and paraconsistent philosophical approaches.

Taught competencies

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</table>

Personal Competencies

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<tr>
<th>Critical Thinking</th>
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851-0562-00L Make Your Own Short Film about Global Development

Research
In this workshop, students will learn how to create a short film about their research related to global sustainable development using their smartphones. They will also reflect on the power of films to reproduce or break prejudices and stereotypes in global development. Short theoretical inputs will be combined with practical work on students' own video projects.

Objective
Students know how to tell an interesting story about their research and how to shoot and cut a short movie using conventional smartphones and laptops.

Content
In this hands-on workshop, students will create a short film about their research in three steps: First, they learn how to choose a topic and tell an interesting story about their research. There will be an opportunity for critical reflection about the danger of reproducing stereotypes and the opportunity of using images to empower people. Second, they will learn how to shoot a short film using a smartphone and what apps and tools can increase the quality of the film. Third, students learn how to cut videos. They receive an introduction to Premiere Pro.

Finally, there will be a "Mini Film Festival" where students show their work and receive feedback. The course will be taught by videographer Katharina Deuber.

Prerequisites / notice

- To participate in the course, students have to bring their own smartphone and need access to a video editing software on their computers/phones (more detailed information will follow before the course)
- Preference is given to doctoral students working on issues related to global development.

851-0298-00L The Modern Literary and Artistic Avantgarde in its European Dimension

Abstract
The modernist Avant-Garde movements are characterized by a radical rhetoric of apocalypse and rebirth, the genesis of another world and a new thinking. The extension of the aesthetic logic into the social fabric (Ehriech), and likewise the intensive examination of the latest technical advancements, new forms of media and their combination, unites them.

Objective
Avant-garde movements are characterized by progressive notions on art, social and political issues as well as by radical criticism on the current circumstances. This is why the specific characteristics of the historic avant-garde of the early 20th century will be a central theme of this lecture: they cannot be separated from the experience of modernity, of the catastrophic course of the First World War, and of the concept of new models of society whose political implementation is a major goal after the end of the war.

The lecture is part of the ‘Science in Perspective’ course programme aimed at enabling the students to deal with avant-garde texts and artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter Bürger's assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-criticism".

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic literature and manifest by Heym, van Hoddis, Werfel, Lasker-Schüler, Toller, Marinetti, Ball, Tzara, Huelsenbeck, Hausmann, Apollinaire, Breton, Goll, and others will be read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of technological innovations, second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and, finally, the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking resilience to totalitarian ideologies.

851-0435-00L Science and Neoliberalism: From the Critique of Planning to Competition and Think Tanks (1930–2000)

Abstract
From its beginning, the history of neoliberal thought has been linked to debates about the status of knowledge in society. In the seminar, students learn to understand fundamental debates in the theory of science in their political and economic contexts; moreover, we explore to what extent neoliberal thinkers actually shaped specific forms of science policy and research funding in the 20th century.

Objective
The seminar promotes an understanding of seminal texts in the early philosophy of science (M. Polanyi, J.D. Bernal, etc.) in the context of ideological struggles in the 1930s and 1940s and of the debates about knowledge, science, and society at that time. Moreover, it provides insights into the political and economic foundations of funding policies for education, science, and research that were developed since the 1970s.

Content
Neoliberalism is considered one of the most influential economic currents since the last decades of the 20th century. However, neoliberalism not only has a much longer history, going back to the ideological struggles of the 1930s. Since then, it has also been closely linked to debates about the status of knowledge and science in society. Theorists of science, such as Michael Polanyi, were part of neoliberal discussion circles; economists, such as Friedrich Hayek, developed decentralized forms of knowledge as part of market processes. In this way, they criticized the contemporary demand for economic planning and the idea of science serving social needs. Competition and the market were subsequently regarded as the most important driving forces for scientific and economic innovation.

Literature

851-0527-00L Introduction to the History of Technology: Concepts, W 3 credits 2S D. Gugerli
The land border between Mexico and the United States, where the 'global North' and the 'global South' meet in the most prominent form
and current debates. The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.

History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

Prerequisites / notice
Beginn 2. Semesterwoche (27.9.2022)

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Type</th>
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<td>851-0516-05L</td>
<td>Mobility and the Border: Migration and Control</td>
<td>W</td>
<td>3</td>
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<td>S. M. Scheuzger</td>
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<tr>
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<td>between Mexico and the USA, 19th–21st Century</td>
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Abstract
The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

Objective
A) The students know relevant approaches of the studies of migration, they are able to assess the analytical capacities of these approaches and they know how to apply them to concrete events and processes.
B) The students have acquired knowledge about important aspects of the history of migration between Mexico and the United States.
C) The students are able to identify relevant relations between scientific and technological change on the one hand and developments of migration and its control on the other.

Content
The historical development of the land border between Mexico and the United States, where the 'global North' and the 'global South' meet in the most prominent form worldwide, provides an exemplary case to study how borders generate spaces of agency, constitute human communities and create identities – not only by separating people but also by connecting them. The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

860-0100-00L Doctoral Colloquium in Public Policy

Abstract
In this colloquium, doctoral students present their research plan within the first year of their doctorate, which is reviewed by three professors affiliated with the ISTP and commented on by the peer students registered in the colloquium. We recommend attending the colloquium for two semesters and present the research plan in the second semester.

Objective
Obtain feedback on research ideas the doctoral research plan and have the research plan approved by three faculty, as required by ETH Zurich.

Content
Doctoral students (typically affiliated with the ISTP or groups of ISTP members) attend this colloquium for one to two semesters. During the first (voluntary) semester they present their preliminary research ideas. During the second (obligatory) semester, they present their research plan, which is reviewed by three professors affiliated with the ISTP. The research plan should not be longer than 20 pages (references excluded). The second semester will be credited with 1 ECTS. All students are supposed to read and comment on their peers' research ideas and plans throughout both semesters. The results of the review are submitted to the doctoral committee of D-GESS or other ETH departments where ISTP-affiliated doctoral students intend to graduate.

851-0252-07L Humans and Social Networks in the Digital Age

Abstract
The digital transformation profoundly impacts humans and how they behave online and offline. Interactions in online social networks offer new opportunities (e.g., political movements, communication) and risks (e.g., fake news, mental health risks). In this seminar, we examine sociological and psychological research on how the digital transformation affects individuals and their (social) behavior.

Learning Objectives:
- Know the most relevant social network terminology and concept
- Know the most relevant sociological and psychological social network theories
- Know the most relevant methods to study online and offline behavior
- Be able to develop meaningful social networks research questions
- Be able to design your own social networks study
- Critically examine empirical research in the field of (online) social networks

Content
The digital transformation has made the “online world” increasingly important for the “offline world”. Hence, interactions in online social networks ultimately affect how people feel, think, behave and interact in offline settings. This course aims to present and structure current debates in online and offline social network research with a focus on social network processes, individual outcomes, and emergent phenomena. By taking a social networks perspective, we view individuals and their behavior in online and offline settings as part of larger social environment and social phenomena as emerging from interconnected social behavior.

851-0534-00L Yemeni Civil War: The Arab Spring, State Formation and Regional Rivalry

Abstract
This course suggests a framework of analysis for the divergent outcomes of the Arab Uprisings (2011) using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain the disintegration of some countries such as Yemen and Libya and the preservation of states such as Egypt and Tunisia.

Objective
1. To get an introduction into the politics of the Middle East and North Africa, the Arab Spring and its divergent outcomes
2. To look at the different forms of state formations within the MENA region
3. To investigate how the interaction between types of state formation and regional context shaped current situation in the post Arab Spring MENA region
4. To look closer at Yemeni Civil War
Countries that experienced popular uprisings in the 2011 Arab Spring had a range of outcomes. Some countries, like Tunisia and Egypt, had a long tradition of centralised state apparatus and a strong national identity. Their outcomes were, respectively, a fragile democratisation process and a reversion to military authoritarianism. Other countries, such as Yemen, Syria and Libya, are newer states that lack a solid national identity, and society is divided along tribal, religious sectarian, linguistic, and/or regional lines. There the outcome has been a meltdown of the political order, along with civil war and fragmentation. Why?

This course suggests a framework of analysis for the divergent outcomes using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain, respectively, the disintegration of countries such as Yemen, Syria and Libya; as well as the preservation of the Bahraini system, despite its ethnic nature. Egypt and Tunisia provide further variants in their well-developed statehood and sense of national identity. Yemen will be used as a case study for examining this complexity among the countries that experienced the Arab spring.

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<thead>
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<th>Number</th>
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### Participation in Commission II (min 1 year)

**900-0113-DRL**

**Only for doctoral students.**

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**Objective**

Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.


### Member of Executive Board (min 1 year)

**900-0114-DRL**

**Only for doctoral students.**

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Active participation in the presidium or executive board of a university group for at least 1 year.

**Objective**

Active participation in the presidium or executive board of a university group for at least 1 year.

**Language Courses ETH/UZH: see Science in Perspective**


### Ethics and Scientific Integrity for Doctoral Students

**851-0178-00L**

This course is interdisciplinary. If your department offers this course, please register there. The following departments offer this course in the fall semester 2022: D-BAUG, D-ERDW, MaP Doctoral School, D-USYS

Doctoral students from D-GESS will have the opportunity to register for a discipline-specific course in spring semester 2023.

**Abstract**

This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

**Objective**

Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

**Content**

**Part I on Moodle**

The self-paced e-learning course on Moodle consists of 5 modules:

- **Module 1: Ethics**
  - Introduction to moral theory (with emphasis on practical guidance regarding decision making)

- **Module 2: Ethics in scientific research**
  - Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

- **Module 3: Collecting resources**
  - A variety of tools and resources that help identify ethical issues are presented and explained

- **Module 4: Setting up a strategy**
  - Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

- **Module 5: Making decisions**
  - Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

**Part II**

The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

For doctoral students only.

**Prerequisites / notice**

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II)

**Taught competencies**

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

- **Method-specific Competencies**
  - Decision-making

- **Personal Competencies**
  - Critical Thinking

- **Integration into Scientific Community**

#### Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
900-0150-DRL | Summer School I (1-3 days) | W | 1 credit | 2K | Lecturers

**900-0151-DRL**

Summer School II (1-3 days)

**Only for doctoral students.**

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Participation in summer or winter schools with a maximum duration of 3 days.

**Objective**

Participation in summer or winter schools with a maximum duration of 3 days.
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Participation in summer or winter schools with a maximum duration of 3 days.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Participation in summer or winter schools with a maximum duration of 3 days.

**Objective**
Participation in summer or winter schools with a maximum duration of 3 days.

**900-0152-DRL**
Summer School III (1-3 days)
Only for doctoral students.

**Abstract**
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**Objective**
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**900-0153-DRL**
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**900-0159-DRL**
Summer School I (min 4 days, with Poster or Talk)
Only for doctoral students.

**Abstract**
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**Objective**
Participation in summer or winter schools with a minimum duration of 4 days.

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Autumn Semester 2022
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**Doctorate Humanities, Social and Political Sciences - Key for Type**

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<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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**Key for Hours**

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<td>colloquium</td>
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<tr>
<td>A</td>
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<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### GCP Basic Course (Modules 1 and 2)

**Abstract**

The basic course in "Good Clinical Practice" (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

**Objective**

Students will get familiar with:
- Key Ethics documents
- (International) Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

**Content**

Module 1:
- Research and Research Ethics, Guidelines, (international) Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
- Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

**Prerequisites / notice**

No compulsory prerequisites, but students should have basic knowledge about biological research.

### Colloquium in Translational Science (Autumn Semester)

**Abstract**

Current topics in translational medicine presented by speakers from academia and industry.

**Objective**

Getting insight into actual areas and problems of translational medicine.

**Content**

Timely and concise presentations of postgraduate students, post-docs, senior scientists, professors, as well as external guests from both academics and industry will present topics of their interest related to translational medicine.

**Prerequisites / notice**

No compulsory prerequisites, but students should have basic knowledge about cardiovascular system, physiology and biomedical research.

### Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging

**Abstract**

The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention.

**Objective**

- Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
- Analyse/compare current molecular/genetic strategies that address these aging problems.
- Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
- Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate research.

**Content**

Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.

**Prerequisites / notice**

No compulsory prerequisites, but students should have basic knowledge about genetics and molecular biology.
Abstract
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Objective

Objective 1:
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2:
Acquire skills to design novel non-invasive technologies for sport and health.

Content
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, texture-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

376-1661-00L Ethics of Life Sciences and Biotechnology
Number of participants limited to 100

W 3 credits 2V

A. Blasimme, E. Vayena

Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and technologies, namely: access to innovation, translational research, and relationships between science and public policy. All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

376-1791-00L Introductory Course in Neuroscience I (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: SPV0Y005

W 2 credits 2V

University lecturers

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Objective
The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.

Content
1) Human Neuroanatomy I&II
2) Comparative Neuroanatomy
3) Building a central nervous system I&II
4) Synapses I&II
5) Glia and more
6) Excitability
7) Circuits underlying Emotion
8) Visual System
9) Auditory & Vestibular System
10) Somatosensory and Motor Systems
11) Learning in artificial and biological neural networks

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Prerequisites / notice
For doctoral students of the Neuroscience Center Zurich (ZNZ).

376-1974-00L Colloquium in Biomechanics W 2 credits 2K

Abstract Current topics in biomechanics presented by speakers from academia and industry.

Objective Getting insight into actual areas and problems of biomechanics.

701-0015-00L Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement W 2 credits 2S
Lecturers B. Vienni Baptista, C. E. Pohl, M. Stauffacher

Abstract This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to help participants’ research projects more societally relevant.

Objective Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content The seminar covers the following topics:
1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants’ research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

Literature Literature will be made available to the participants.

The following open access article builds a core element of the course:
available at (open access): http://www.ingentaconnect.com/content/one/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

Prerequisites / notice Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Problem-solving</td>
<td>Cooperation and Teamwork</td>
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Food Science

Number Title Type ECTS Hours Lecturers
752-0005-00L Colloquium in Food and Nutrition Science W 1 credit 2K S. J. Sturla

Abstract Participation in weekly seminars on a variety of topics including Food Microbiology, Food Toxicology, Food Biochemistry, Food Processing, Consumer Behavior, Food Technology, and Food Materials and Technology, and oral presentation of a selected published study in one of these areas inspired by participation in the seminars.

Objective The objectives are to become familiar with and stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the semester presentations.

Transferable Skills

Number Title Type ECTS Hours Lecturers
900-0100-DRL Transferable Skills Course I (1-3 days) W 1 credit 2S Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0101-DRL Transferable Skills Course II (1-3 days) W 1 credit 2S Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0102-DRL Transferable Skills Course III (1-3 days) W 1 credit 2S Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
Abstract | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
---
Objective | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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or Talk)
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>900-0112-DRL</td>
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<td>Lecturers</td>
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<tr>
<td>900-0113-DRL</td>
<td>Participation in Commission II (min 1 year)</td>
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<tr>
<td>900-0114-DRL</td>
<td>Member of Executive Board (min 1 year)</td>
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<td>2</td>
<td>4P</td>
<td>Lecturers</td>
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Integration into Scientific Community

Educational Science for Teaching Diploma and TC

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>900-0152-DRL</td>
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<td>2K</td>
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<td>Summer School I (1-3 days, with Poster or Talk)</td>
<td>W</td>
<td>2</td>
<td>4K</td>
<td>Lecturers</td>
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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

**900-0154-DRL** Summer School II (1-3 days, with Poster or Talk)  
**W**  2 credits  4K  Lecturers

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Abstract Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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**900-0155-DRL** Summer School III (1-3 days, with Poster or Talk)  
**W**  2 credits  4K  Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

**900-0156-DRL** Summer School I (min 4 days)  
**W**  2 credits  4K  Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days.

Objective Participation in summer or winter schools with a minimum duration of 4 days.

**900-0157-DRL** Summer School II (min 4 days)  
**W**  2 credits  4K  Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days.

Objective Participation in summer or winter schools with a minimum duration of 4 days.

**900-0158-DRL** Summer School III (min 4 days)  
**W**  2 credits  4K  Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days.

Objective Participation in summer or winter schools with a minimum duration of 4 days.

**900-0159-DRL** Summer School I (min 4 days, with Poster or Talk)  
**W**  3 credits  6K  Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

**900-0160-DRL** Summer School II (min 4 days, with Poster or Talk)  
**W**  3 credits  6K  Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

**900-0161-DRL** Summer School III (min 4 days, with Poster or Talk)  
**W**  3 credits  6K  Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
**Abstract**

Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

**Objective**

Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

<table>
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<tr>
<th>Code</th>
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<td>Abstract</td>
<td>Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.</td>
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**Doctorate Health Sciences and Technology - Key for Type**

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<th>Grade</th>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>O</td>
<td>Compulsory</td>
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**Key for Hours**

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

**ECTS**

European Credit Transfer and Accumulation System

*Special students and auditors need special permission from the lecturers.*
Seminar in Theoretical Computer Science
1 credit
ECTS
A. Ilic
3S
2S W

Technology has the potential to transform our society. But without the right team & funding, some break-throughs will never see the light of day. This seminar helps aspiring student/research entrepreneurs to understand how to fund their path from research into practice. The examples and cases will be primarily from software, AI, and other deep-tech ventures.

Abstract
An essential aspect of any research project is dissemination of the findings arising from the study. Here we focus on oral communication, which includes: appropriate selection of material, preparation of the visual aids (slides and/or posters), and presentation skills.

Objective
The seminar participants should learn how to prepare and deliver scientific talks as well as to deal with technical questions. Participants are also expected to actively contribute to discussions during presentations by others, thus learning and practicing critical thinking skills.

Content
The course is practically oriented and features guest speakers from leading venture capital firms and start-ups. The course embraces a unique perspective combining technology and investor thinking. The seminar is structured around five days with the following themes.

- Write their first software/AI-related invention disclosure suitable for patenting
- Conduct patent searches, freedom-to-operate analysis and infringement analyses
- Effectively use patents as a cost-effective part of a technology startup's business plan
- Evaluate patenting opportunities with a more differentiated view on the topic

Prerequisites / notice
This doctoral seminar is intended for PhD students who work on machine learning projects, i.e., for the PhD students of the ML lab.

Number of participants limited to 50.

- Explain the differences between VC and founder thinking
- Evaluate if a start-up is suited for venture capital ("VC readiness")
- Evaluate founder friendliness of term sheets
- Determine funding needs & strategy for a start-up from research to first round
- Write and evaluate an investment memo

Number of participants limited to 50.

- The macro picture. Why does venture capital exist? What are major tech break-through areas and their disruptive potential? We also review the differences in the US and European perspective as well as developments towards more impact and diversity conscious funds.
- A peek into the mind of a VC. How to build a successful VC? Learn what key factors & processes required to build a successful venture capital company. This includes strategic decisions for investment thesis, structure of a fund, portfolio economics, valuation & ownership targets, etc.
- The founder's perspective. Why should you raise venture capital and how? Learn to evaluate the founder friendliness of terms, company approach, strategic decisions, negotiation and valuation.
- Fundraising types. Learn about different types of funding and their implications. This includes an overview of the Swiss ecosystem and a discussion of the different types (grants, equity, loans, SAFE, crowd, …). We also include a practical session on crypto technology for modern fund-raising using launchpads and tokenized shares.

Tying it all together. The last day is focused on simulating an investment committee meeting where the groups present their deal memos and discuss with the audience.

Patenting Digital Innovations
1 credit
ECTS
A. Illic, B. Best
2S W

In this seminar dedicated to digital innovations, we will bust the most stubborn myths around AI software patents such as "Software/AI isn't patentable", "AI patents are useless because you can't figure out if they are infringed", and many others. We will look at how AI and software start-ups can use patents to create a strong IP position in a scalable way.

Abstract
In the US and European perspective as well as developments towards more impact and diversity conscious funds.

Objective
After attending this course, students will be able to:
- Understand the basics of patenting in the digital space relevant for a global market
- Evaluate patenting opportunities with a more differentiated view on the topic
- Effectively use patents as a cost-effective part of a technology startup's business plan
- Conduct patent searches, freedom-to-operate analysis and infringement analyses
- Write their first software/AI-related invention disclosure suitable for patenting
### Foundations of Reinforcement Learning (Only Assignments)

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of Course</th>
<th>Credits</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-S255-10L</td>
<td>Foundations of Reinforcement Learning (Only Assignments)</td>
<td>2 credits</td>
<td>This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets students with strong research interests in reinforcement learning, optimization under uncertainty, and data-driven control.</td>
</tr>
</tbody>
</table>

**Note:** This course is only for Ph.D. students.

**Content:**
- Understanding the needs of different target readerships,
- Managing the writing process efficiently,
- Structuring texts effectively,
- Producing logical flow in sentences and paragraphs,
- Editing texts before submission, and
- Revising texts in response to colleagues’ feedback and reviewers’ comments.

**Abstract:**
In this doctoral seminar, current research at the Institute for Visual Computing will be presented and discussed. The goal is to learn about current research projects at our institute, to strengthen our expertise in the field, to provide a platform where research challenges can be discussed, and also to practice scientific presentations.

**Objective:**
Participants will be expected to produce a number of short texts (e.g., draft of a conference abstract) as homework assignments; they will receive individual feedback on these texts during the course. Wherever feasible, elements of participants’ future conference/journal articles can be developed as assignments within the course, so it is likely to be particularly useful for those who have i) their data and are about to begin the writing process, or ii) an MSc thesis they would like to convert for publication.

**Number of participants limited to 15.**

**Prerequisites / notice:**
- Any interested students are welcome. This course will be offered again in FS23!
- Only for D-INFK doctoral students.

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### Writing for Publication in Computer Science (WPCS)

#### Writing for Publication in Computer Science A (WPCS) Z

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of Course</th>
<th>Credits</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>264-S812-00L</td>
<td>Writing for Publication in Computer Science A (WPCS) Z</td>
<td>2 credits</td>
<td>This course requires solid knowledge in the area of Computer Graphics and Computer Vision as well as state-of-the-art research.</td>
</tr>
</tbody>
</table>

**Number of participants limited to 15.**

**Abstract:**
Writing for Publication in Computer Science is a short course (5 x 4-lesson workshops) designed to help doctoral students develop the skills needed to write their first research articles. The course deals with topics such as:
- Understanding the needs of different target readerships,
- Managing the writing process efficiently,
- Structuring texts effectively,
- Producing logical flow in sentences and paragraphs,
- Editing texts before submission, and
- Revising texts in response to colleagues’ feedback and reviewers’ comments.

**Prerequisites / notice:**
- Some participants will begin the writing process, or ii) an MSc thesis they would like to convert for publication.
- IP experts are joining the seminar as guest speakers for discussion of real-life examples.

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### Writing for Publication in Computer Science B (WPCS) Z

<table>
<thead>
<tr>
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<th>Name of Course</th>
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<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>264-S813-00L</td>
<td>Writing for Publication in Computer Science B (WPCS) Z</td>
<td>2 credits</td>
<td>This short course is designed to help junior researchers in Computer Science develop the skills needed to write their first research articles.</td>
</tr>
</tbody>
</table>

**Number of participants limited to 15.**

**Abstract:**
Writing for Publication in Computer Science is a short course (5 x 4-lesson workshops) designed to help doctoral students develop the skills needed to write their first research articles. The course deals with topics such as:
- Understanding the needs of different target readerships,
- Managing the writing process efficiently,
- Structuring texts effectively,
- Producing logical flow in sentences and paragraphs,
- Editing texts before submission, and
- Revising texts in response to colleagues’ feedback and reviewers’ comments.

**Prerequisites / notice:**
- Any interested students are welcome. This course will be offered again in FS23!
- Only for D-INFK doctoral students.

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### Big Data

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</tr>
</thead>
<tbody>
<tr>
<td>263-3010-00L</td>
<td>Big Data</td>
<td>10 credits</td>
<td>The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.</td>
</tr>
</tbody>
</table>

**Abstract:**
The seminar includes presentations and practical group exercises to apply the acquired knowledge in practice. Entrepreneurs and leading IP experts are joining the seminar as guest speakers for discussion of real-life examples.

**Topics that will be covered include:**
- Best practices that any AI/software startups should know about IP and patents,
- How investors evaluate a strong IP situation of a start-up,
- How to efficiently monitor competitor patent activity and obtain “FTO”,
- How to create an effective patent filing strategy that grows with the business,
- How to efficiently create AI patents while not getting distracted from the founder’s core business.

The seminar also contains a group work of a “FTO battle” where two teams compete in a freedom-to-operate analysis and individual work to write their first invention disclosure related to an AI or software topic.
This combination of requirements, together with the technologies that have emerged in order to address them, is typically referred to as "Big Data." This revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lectures will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.

This course is interdisciplinary. If your department offers this course in the fall semester 2022: D-BAUG, D-ERDW, MaP Doctoral School, D-USYS

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021
- "Information Systems for Engineers" (SQL, relational databases): this Fall

Large scale analytics and machine learning are outside of the scope of this course.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

This course is only intended for:
- Computer Science students
- Data Science students
- CB students with a Computer Science background

This course is only intended for:
- Computer Science students
- Data Science students
- CB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021
- "Information Systems for Engineers" (SQL, relational databases): this Fall

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

<table>
<thead>
<tr>
<th>Transferrable Skills</th>
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<tr>
<td>Number</td>
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<td>851-0178-00L</td>
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</table>

Doctoral students from D-GESS will have the opportunity to register for a discipline-specific course in spring semester 2023.

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.
Part I on Moodle

The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II

The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice

For doctoral students only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II)

Taught competencies

For doctoral students only.

Subject-specific Competencies
- Decision-making
- Problem-solving

Method-specific Competencies
- Critical Thinking
- Integrity and Work Ethics

Personal Competencies
- Concepts and Theories assessed
- Decision-making assessed
- Problem-solving assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed

Research Ethics

W 2 credits 2G G. Achermann, P. Emch

Number of participants limited to 40

Particularly suitable for students of D-BIOL, D-CHAB, D-HEST

Abstract

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective

Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning

1. Ethics - the basics
   1.1 What ethics is not…
   1.2 Recognising an ethical issue (awareness)
   1.3 What is ethics? Personal, cultural and ethical values, principles and norms
   1.4 Ethics: a classification
   1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
   2.1 What is normative ethics? Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories
   2.3 The plurality of normative theories (moral pluralism)
   2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
   3.1 How (not) to approach ethical issues
   3.2 What is a moral dilemma? Is there a correct method for answering moral questions?
   3.3 Methods of making ethical decisions
   3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
   1.1 What is research integrity and why is it important?
   1.2 What is research misconduct?
   1.3 Questionable/Detrimental Research Practice (QRP/DRP)
   1.4 What is the incidence of misconduct?
   1.5 What are the factors that lead to misconduct?
   1.6 Responding to research wrongdoing
   1.7 The process of dealing with misconduct
   1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
   2.1 Data collection and recordkeeping
   2.2 Analysis and selection of data
   2.3 The (mis)representation of data
   2.4 Ownership of data
   2.5 Retention of data
   2.6 Sharing of data (open research data)
   2.7 The ethics of big data

3. Publication ethics / Responsible publishing
   3.1 Background
   3.2 Criteria for being an author
   3.3 Ordering of authors
   3.4 Publication practices

III. Research Ethics – External responsibilities

1. Research involving human subjects
   1.1 History of research with human subjects
   1.2 Basic ethical principles – The Belmont Report
   1.3 Requirements to make clinical research ethical
   1.4 Social value and scientific validity
   1.5 Selection of study participants – the concept of vulnerability
   1.6 Favourable risk-benefit ratio
   1.7 Independent review - Ethics Committees
   1.8 Informed consent
   1.9 Respect for potential and enrolled participants

2. Social responsibility
   2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media
   2.3 Public advocacy (policy making)

3. Dual use research
   3.1 Introduction to Dual use research
   3.2 Case study – Censuring science?
   3.3 Transmission studies for avian flu (H5N1)
   3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
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</tbody>
</table>

851-0745-00L Ethics Workshop: The Impact of Digital Life on Society

W 2 credits 2S
E. Vayena, A. Blasimme, A. Ferretti, C. Landers, J. Sleigh

Open to all Master level / PhD students.

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.
### Content

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, news media, society, social media, digital health and justice will be then considered. These six domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explain-ability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Duration</th>
<th>Instructor</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days)</td>
<td>1</td>
<td>2S</td>
<td>Lecturers</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.</td>
</tr>
<tr>
<td>900-0101-DRL</td>
<td>Transferable Skills Course II (1-3 days)</td>
<td>1</td>
<td>2S</td>
<td>Lecturers</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.</td>
</tr>
<tr>
<td>900-0102-DRL</td>
<td>Transferable Skills Course III (1-3 days)</td>
<td>1</td>
<td>2S</td>
<td>Lecturers</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.</td>
</tr>
<tr>
<td>900-0103-DRL</td>
<td>Transferable Skills Course I (1-3 days, with Poster or Talk)</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
</tr>
<tr>
<td>900-0104-DRL</td>
<td>Transferable Skills Course II (1-3 days, with Poster or Talk)</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
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<td>900-0105-DRL</td>
<td>Transferable Skills Course III (1-3 days, with Poster or Talk)</td>
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<td>4S</td>
<td>Lecturers</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
</tr>
<tr>
<td>900-0106-DRL</td>
<td>Transferable Skills Course I (min 4 days)</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
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</tbody>
</table>

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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<tbody>
<tr>
<td>900-0107-DRL</td>
<td>Transferable Skills Course II (min 4 days)</td>
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<td>4S</td>
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<tr>
<td>900-0108-DRL</td>
<td>Transferable Skills Course III (min 4 days)</td>
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<td>2</td>
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<tr>
<td>900-0109-DRL</td>
<td>Transferable Skills Course I (min 4 days, with Poster or Talk)</td>
<td>W</td>
<td>3</td>
<td>6S</td>
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<tbody>
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<td>900-0110-DRL</td>
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</tr>
</thead>
<tbody>
<tr>
<td>900-0111-DRL</td>
<td>Transferable Skills Course III (min 4 days, with Poster or Talk)</td>
<td>W</td>
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<tbody>
<tr>
<td>900-0112-DRL</td>
<td>Participation in Commission I (min 1 year)</td>
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Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

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<tr>
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<tr>
<td>900-0114-DRL</td>
<td>Member of Executive Board (min 1 year)</td>
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**Abstract**
Active participation in the presidium or executive board of a university group for at least 1 year.

**Objective**
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Course units in Humanities, Social and Political Sciences

Course units in Management, Technology and Economics

**Integration into Scientific Community**

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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>900-0150-DRL</td>
<td>Summer School I (1-3 days)</td>
<td>W</td>
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</table>

| 900-0151-DRL | Summer School II (1-3 days)                      | W    | 1 credit | 2K   | Lecturers |
|             | Only for doctoral students.                    |      |       |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Participation in summer or winter schools with a maximum duration of 3 days. |

| 900-0152-DRL | Summer School III (1-3 days)                     | W    | 1 credit | 2K   | Lecturers |
|             | Only for doctoral students.                    |      |       |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Participation in summer or winter schools with a maximum duration of 3 days. |

| 900-0153-DRL | Summer School I (1-3 days, with Poster or Talk)  | W    | 2 credits | 4K   | Lecturers |
|             | Only for doctoral students.                    |      |       |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0154-DRL | Summer School II (1-3 days, with Poster or Talk) | W    | 2 credits | 4K   | Lecturers |
|             | Only for doctoral students.                    |      |       |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0155-DRL | Summer School III (1-3 days, with Poster or Talk) | W    | 2 credits | 4K   | Lecturers |
|             | Only for doctoral students.                    |      |       |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0156-DRL | Summer School I (min 4 days)                    | W    | 2 credits | 4K   | Lecturers |
|             | Only for doctoral students.                    |      |       |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Participation in summer or winter schools with a minimum duration of 4 days. |

| 900-0157-DRL | Summer School II (min 4 days)                   | W    | 2 credits | 4K   | Lecturers |
|             | Only for doctoral students.                    |      |       |       |           |
| Abstract    | Participation in summer or winter schools with a minimum duration of 4 days. |
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<td>Summer School I (min 4 days, with Poster or Talk)</td>
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<td>900-0161-DRL</td>
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<tr>
<td>900-0162-DRL</td>
<td>External Conference I (incl. Poster or Talk)</td>
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### Doctorate Computer Science - Key for Type

<table>
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<tr>
<th>Key</th>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>O</td>
<td>Compulsory</td>
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### Key for Hours

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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS

**European Credit Transfer and Accumulation System**

Special students and auditors need special permission from the lecturers.
### Doctorate Information Technology and Electrical Engineering


**Subject Specialisation**

A minimum of 12 ECTS credit points must be obtained during doctoral studies.

The courses on offer below are only a small selection out of a much larger available number of courses. Please discuss your course selection with your PhD supervisor.

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>227-0150-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
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<tr>
<td>227-0160-00L</td>
<td>Advanced Model Predictive Control</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>M. Zeilinger, A. Carron, L. Hewing, J. Köhler</td>
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</tbody>
</table>

### Content

**Abstract**

Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

**Objective**

Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations. Topics include:

- Review of Bayesian statistics, stochastic systems and Stochastic Optimal Control
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

**Lecture notes**

Lecture notes will be provided.

**Prerequisites / notice**

Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended. Background in linear algebra and stochastic systems recommended.

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<tr>
<td>227-0146-00L</td>
<td>Analog-to-Digital Converters</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>T. Burger</td>
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</table>

### Content

**Abstract**

Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. The student will learn to understand the basic principles behind data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained with their principle of operation accompanied with the appropriate mathematical calculations, including the effects of non-idealities in some cases. After successful completion of the course the student should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.

**Objective**

Students master the basic mathematical concepts and algorithms of estimation and machine learning.

**Content**

- Introduction: information representation and communication; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.
- Dual-slope & successive approximation register (SAR) converters: dual slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.
- Algorithmic & pipelined A/D converters: algorithmic conversion principle; sample & hold stage; pipe-lined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.
- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.
- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkile correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.
- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-oder delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.

**Lecture notes**

Slides are available online under [https://is-students.ee.ethz.ch/lectures/analog-to-digital-converters/](https://is-students.ee.ethz.ch/lectures/analog-to-digital-converters/)

**Prerequisites / notice**

It is highly recommended to attend the course “Analog Integrated Circuits” of Prof. T. Jang as a preparation for this course.

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<tr>
<td>227-0125-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>J. Lygeros, A. Tsiamis</td>
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</table>
The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity, optimal experimental design, Cramer-Rao bounds, input signal design, Parametric identification methods. On-line and batch approaches, Closed-loop identification strategies. Trade-off between controller performance and information available for identification, "System Identification; Theory for the User" Lennart Ljung, Prentice Hall (2nd Ed), 1999.

Additional papers will be available via the course Moodle.

Seminar in Electromagnetics, Photonics and Terahertz

Abstract
Selected topics of the current research activities at the IEF and closely related institutions are discussed. Have an overview on the research activities of the IEF institute.

Objective
This colloquium for MSc/PhD students at D-ITET discusses research in Translational Neuromodeling (development of mathematical models for diagnostics of brain diseases) and application to Computational Psychiatry/Psychosomatics. The range of topics is broad, incl. computational (generative) modeling, experimental paradigms (fMRI, EEG, behaviour), and clinical questions. See above

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Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Literature**

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**252-0417-00L Randomized Algorithms and Probabilistic Methods**
- **W** 10 credits 3V+2U+4A
- A. Steger

**Abstract**
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

**Objective**
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**
Randomized Algorithms are algorithms that “flip coins” to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Lecture notes**
Yes.

**Literature**

**327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation**
- **W** 2 credits 2G
- M. Trassin

**Abstract**
The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed.

Oxide electronics device concepts will be discussed.

**Objective**
Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these (“multiferroics”).

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

**Content**
Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

**401-3055-64L Algebraic Methods in Combinatorics**
- **W** 6 credits 2V+1U
- B. Sudakov

*Does not take place this semester.*

**Abstract**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

401-5680-00L Foundations of Data Science Seminar Z 0 credits P. L. Bühlmann, A. Bandeira, H. Bölcskei, S. van de Geer, F. Yang

**Research colloquium**

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Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**Objective**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**900-0113-DRL**  
**Participation in Commission II (min 1 year)**  
W 1 credit 2P Lecturers

Absenteeism is allowed only in case of force majeure. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**Objective**
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

**900-0114-DRL**  
**Member of Executive Board (min 1 year)**  
W 2 credits 4P Lecturers

Absenteeism is allowed only in case of force majeure. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**
Active participation in the presidium or executive board of a university group for at least 1 year.

**Objective**
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

### Integration into Scientific Community

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| Objective   | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0158-DRL | Summer School III (min 4 days)      | W 2 credits | 4K Lecturers |
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| Objective   | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0159-DRL | Summer School I (min 4 days, with Poster or Talk) | W 3 credits | 6K Lecturers |
| Abstract    | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |
| Objective   | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0160-DRL | Summer School II (min 4 days, with Poster or Talk) | W 3 credits | 6K Lecturers |
| Abstract    | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |
| Objective   | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0161-DRL | Summer School III (min 4 days, with Poster or Talk) | W 3 credits | 6K Lecturers |
| Abstract    | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |
| Objective   | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0162-DRL | External Conference I (incl. Poster or Talk) | W 1 credit | 2K Lecturers |
| Abstract    | Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. |
| Objective   | Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. |

| 900-0163-DRL | External Conference II (incl. Poster or Talk) | W 1 credit | 2K Lecturers |
| Abstract    | Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. |
| Objective   | Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. |

| 900-0164-DRL | External Conference III (incl. Poster or Talk) | W 1 credit | 2K Lecturers |
| Abstract    | Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. |
| Objective   | Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. |
and prove your participation with the appropriate certificate.

Abstract Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Doctorate Information Technology and Electrical Engineering - Key for Type**

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**Key for Hours**

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<td>practical/laboratory course</td>
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<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Subject Specialisation

- **Management**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>364-1013-05L</td>
<td>Organizational Behavior</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>F. Magni</td>
</tr>
<tr>
<td>Number of participants limited to 20.</td>
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<tr>
<td>Abstract</td>
<td>Organizational behavior concerns the study of individual and group-level processes in organizations like creativity, motivation, and leadership. In this PhD course, an overview of major concepts and research insights in organizational behavior is provided. The participants are encouraged to discuss their own work situation as PhD students in relation to the OB insights covered in the course.</td>
<td></td>
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</tbody>
</table>
| Objective | The objectives of the course are:  
- to provide an overview of OB research  
- to discuss major research streams in OB  
- to enable students to reflect their own work situation based on concepts used in OB. |

| 364-1013-06L | Marketing Theory                          | W    | 2 credits | 1G   | F. von Wangenheim   |
| Number of participants limited to 18. |
| Abstract | The course is taught Florian Wangenheim (ETHZ). It focuses on the theoretical foundations of marketing and marketing research. |
| Objective | The purpose of the course is to confront students with current theoretical thinking in marketing, and currently used theories for understanding and explaining buyer and customer behavior in response to marketing action. In the following classes, various theories are discussed, particularly in light of their importance for marketing. Economic, psychological and sociological theory will be related to current marketing thought. |

| 364-1110-00L | Foundations of Innovation Studies         | W    | 3 credits | 2G   | S. Brusoni         |
| Number of participants limited to 18. |
| Abstract | This course will introduce some of the major theoretical threads and controversies in the broad field of innovation. During the first part of the course, the emphasis will be on the evolution of innovation studies. The final part of the course will focus on one of the directions in which those studies have evolved: the field of managerial cognition. |
| Objective | Students will learn about various perspectives, examine different methodologies, explore some original empirical research, make connections between theory and empirical research, and practice reviewing and identifying insight in research.  
1) Be able to display some knowledge on a few major theoretical streams in the area.  
2) Be familiar with the methods, issues and current gaps in the area.  
3) Have practiced skills in finding insight and reviewing the literature.  
4) Have practiced skills in defining research problems and proposing empirical research in this area. |

| 364-0553-00L | Innovation in Digital Space               | W    | 1 credit | 1G   | G. von Krogh, to be announced |
| Number of participants limited to 18. |
| Abstract | The purpose of this course is to review and discuss issues in current theory and research relevant to innovation in the digital space. |
| Objective | Through in-depth analysis of published work, doctoral candidates will identify and appraise theoretical and empirical studies, formulate research questions, and improve the positioning of their own research within the academic debate. |
| Content | The Internet has a twofold impact on the way individuals and firms innovate. First, firms increasingly draw on digital technology to access and capture innovation-relevant knowledge in their environment. Second, individuals, firms, and other organizations extensively utilize the Internet to create, diffuse, and commercialize new digital products and services. During the past decade, theory and research on innovation in the digital space has flourished and generated extensive insights of relevance to both academia and management practice. This has brought us better understanding of working models, and some fundamental reasons for innovation success or failure. A host of new models and research designs have been created to explore the innovation in the digital space, but these have also brought out many open research questions. We will review some of the existing streams of work, and in the process explore a new research agenda. |
| Format | The course is organized in one block of 2 days. The course is a combination of pre-readings, presentations by faculty and students, and discussions. The students prepare presentations of papers in order to facilitate analysis and discussion. |
The course contains three blocks that are mostly based on the three learning objectives presented above. Hacking for Social Sciences does not contain a strong programming component. Yet this course argues that what the open source community calls a 'software carpentry' profound methodological knowledge is not a prerequisite.

Non-Goals:
- Applied data sourcing and data transformation
- Learn how to manage and version control source code.
- Understand the role of focal components in a data science tech toolbox.
- Abstract

Objective
The idea behind Hacking for Social Sciences is build a solid understanding of core technologies and concepts to help researchers develop a data processing strategy and increase your possibilities when working with data. The course approach is to single out those concepts stemming from software development that are easy to adopt and useful to social scientists. The course has three major learning objectives:
- The vast majority of data has been created within the last decade. As a result, more and more fields of research start to consider and embrace programming to process and analyse data. This course teaches applied programming with data and aims to leverage the open source tech stack to deal with this new wealth and complexity of data.

Abstract
The first block demonstrates the components of a modern data science tech stack, classifies technologies and gives a big picture overview: from languages such as R and Python to container technology such as docker. The second block focuses on git version control, the de facto industry standard to manage source code. Version control is not only crucial to knowledge management and reproducible research, but it is also the backbone of collaboration in distributed teams. The third and final block focuses on data itself and teaches how to obtain data through machine to machine communication.

Non-Goals:
- Hacking for Social Sciences is not a Statistics, Econometrics or Machine Learning course. Though experience in these fields will help inasmuch that students will have an easier time to motivate investing in programming and to come up with their own application examples, profound methodological knowledge is not a prerequisite.

Content
Hacking for Social Scientists is a guide to programming with data. It is tailored to the needs of a field in which scholars’ typical curricula do not contain a strong programming component. Yet this course argues that what the open source community calls a ‘software carpentry’ level is totally within reach for a quantitative social scientist and well worth the investment: being able to code leverages field specific expertise and fosters interdisciplinary collaboration, as source code continues to become an important communication channel.

The course contains three blocks that are mostly based on the three learning objectives presented above. Hacking for Social Sciences explicitly plans to spread its three blocks over 1-2 months to give students the ability to work on applied examples in between sessions in order to get most out of the subsequent session.

The first block demonstrates the components of a modern data science tech stack, classifies technologies and gives a big picture overview: from languages such as R and Python to container technology such as docker. The second block focuses on git version control, the de facto industry standard to manage source code. Version control is not only crucial to knowledge management and reproducible research, but it is also the backbone of collaboration in distributed teams. The third and final block focuses on data itself and teaches how to obtain data through machine to machine communication. Furthermore, the third block discusses data management in a research project.

Lecture notes
A free and open online book (made with bookdown) is available from https://h4scl.github.io/h4scl-book/. The book/script will be continuously updated during the course to account for questions and participants’ questions.

All course materials including, slides, resources and source code will be made available through: https://h4scl.github.io/
The course focuses on important factors that drive the innovation performance of firms, like innovation capabilities, the use of digital technologies, environmental and innovation policy and it shows how innovation activities relate to firm performance and to the technological dynamics of industries. We also discuss the implications of the findings for effective economic policy-making.

Literature

- A free and open online book (made with bookdown) is available from https://h4sci.github.io/h4sci-book/. The book/script will be continuously updated during the course to account for questions and participants' questions.
- All course materials including, slides, resources and source code will be made available through: https://h4sci.github.io/

Prerequisites / notice

- Basic experience with either R or Python, e.g., a stats course that was taught using R.

Economics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>364-1090-00L</td>
<td>Research Seminar in Contract Theory, Banking and Money (University of Zurich)</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>H. Gersbach, University lecturers</td>
</tr>
<tr>
<td>363-1036-00L</td>
<td>Empirical Innovation Economics</td>
<td>W</td>
<td>3 credits</td>
<td>1G</td>
<td>M. Wörter</td>
</tr>
</tbody>
</table>

Abstract

Recent developments in the fields of contract theory, finance, banking, money and macroeconomics.

Objective

Understanding recent developments in the fields of contract theory, finance, banking and macroeconomics.

Prerequisites


Content

- The course consists of two parts. Part I provides an introduction into important topics in the field of the economics of innovation. Part II consists of empirical exercises based on various firm-level data sets, e.g., the KOF Innovation data, data about the digitization of firms, data about environmentally friendly innovations, or patent data. In part I, we will learn about (a) market conditions that encourage firms to invest in R&D (Research and Development) and develop new products and processes. (b) the role of competition and market structure for the R&D activities of companies. (c) how digital and environmentally friendly technologies diffuse among firms. (d) how the R&D activities of firms are affected by economic crises and how firms finance their R&D activities. (e) how we can measure the returns to R&D activities. (f) how environmental policies and innovation policies affect the technological activities of a firm. In part II we will use the KOF Innovation Survey data, patent data, data on digitization of firms, or other longitudinal data sources, to investigate empirically the technological activities of firms in relation to the topics introduced in part I.

Literature

- For an overview of cutting-edge results of current research see G.M. Peter Swann, The Economics of Innovation - an Introduction, Edward Elgar, 2009.

Prerequisites / notice

- Course is directed to advanced Master-Students and PhD Students with an interest in empirical studies.

Economics

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>364-0531-00L</td>
<td>CER-ETH Research Seminar</td>
<td>E</td>
<td>0 credits</td>
<td>2S</td>
<td>H. Gersbach, A. Bommier, L. Bretschger</td>
</tr>
<tr>
<td>364-0556-00L</td>
<td>Doctoral Workshop: Astute Modelling</td>
<td>W</td>
<td>3 credits</td>
<td>1G</td>
<td>H. Gersbach</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 710 of 2345
In this workshop, ongoing research is presented and the criteria and guidelines for astute modelling of economic, political, and social situations are discussed.

We will learn how to craft models, how to present our own research and improve our analytical skills.

Students are expected to attend the doctoral course "Macroeconomic Dynamics" before registering for this workshop.

**364-0585-00L**  
**PhD Course: Applied Econometrics**  
**W**  
**2 credits**  
**2V**  
**P. Egger**

**Abstract**  
In this course, we will address three blocs of selected problems: (i) estimation of fixed and random effects panel data models for single equations and systems of equations; (ii) estimation of models with endogenous treatment effects or sample selection; (iii) estimation of models with interdependent data (so-called spatial models).

**Objective**  
The main agenda of this course is to familiarize students with the estimation of econometric problems with three alternative types of problems: (i) estimation of fixed and random effects panel data models for single equations and systems of equations; (ii) estimation of models with endogenous treatment effects or sample selection; (iii) estimation of models with interdependent data (so-called spatial models). Students will be able to program estimation routines for such problems in STATA and apply them to data-sets. They will be given a data-set and will have to work out empirical problems in the context of a term paper.

**Lecture notes**  


For spatial econometrics:  
I will mostly use papers.

I will prepare a script (based on slides), covering all topics.

**364-0581-00L**  
**Microeconomics Seminar (ETH/UZH)**  
**E-**  
**0 credits**  
**2S**  
**H. Gersbach**

**Abstract**  
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 03SMDOEC6089

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

**Objective**  
Research Seminar research papers of leading researchers in Microeconomics are presented and discussed

**Content**  
Research Seminar research papers of leading researchers in Microeconomics are presented and discussed

**364-1025-00L**  
**Advanced Microeconomics**  
**E-**  
**3 credits**  
**2G**  
**A. Bommier**

**Abstract**  
The objective of the course is to provide students with advanced knowledge in some areas of micro economic theory. The course will focus on 1) Individual behavior 2) Collective behavior 3) Choice under uncertainty 4) Intertemporal choice.

**Objective**  
The aim is to give to the students the opportunity to review the key results in rational individual behavior, collective models, choice under uncertainty, intertemporal choice, as well as to get some insights on more recent advances in those areas.

The course is therefore designed for students who have some interest for research in economics.

**Content**  
The following topics will be addressed;  
2) Collective models. Cooperative and non cooperative models of household behavior.  
3) Choice under uncertainty. The foundations of expected utility theory. Some insights on other approaches to choice under uncertainty.  
4) Intertemporal choice. Dynamic model. Life cycle theory.

**Literature**  
The course will be based on some chapters of the books: “Advanced Microeconomic Theory” by Jehle and Reny (2011) and “Microeconomic Theory”, by Mas-Colell, Whinston and Green (1995), as well as research articles for the most advanced parts.

**364-1058-00L**  
**Risk Center Seminar Series**  
**Z**  
**0 credits**  
**2S**  

**Abstract**  
This course is a mixture between a seminar primarily for PhD and postdoc students and a colloquium involving invited speakers. It consists of presentations and subsequent discussions in the area of modeling complex socio-economic systems and crises. Students and other guests are welcome.

**Objective**  
Participants should learn to get an overview of the state of the art in the field, to present it in a well understandable way to an interdisciplinary scientific audience, to develop novel mathematical models for open problems, to analyze them with computers, and to defend their results in response to critical questions. In essence, participants should improve their scientific skills and learn to work scientifically on an internationally competitive level.

**Content**  
This course is a mixture between a seminar primarily for PhD and postdoc students and a colloquium involving invited speakers. It consists of presentations and subsequent discussions in the area of modeling complex socio-economic systems and crises. For details of the program see the webpage of the colloquium. Students and other guests are welcome.

**Lecture notes**  
There is no script, but a short protocol of the sessions will be sent to all participants who have participated in a particular session.

**Literature**  
Transparencies of the presentations may be put on the course webpage.

**Prerequisites / notice**  
Literature will be provided by the speakers in their respective presentations.

**364-1015-00L**  
**KOF-ETH-UZH International Economic Policy Seminar**  
**W**  
**University of Zurich**  
**2 credits**  
**2S**  
**P. Egger, J.-E. Sturm, University lecturers**
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 03SMDOEC1028

Mind the enrolment deadlines at UZH:

Abstract
In this seminar series, which is held jointly with Prof. Dr. Woitek and Prof. Dr. Hoffman from the University of Zurich, distinguished international researchers present their current research related to international economic policy. The participating doctoral students are expected to attend the presentations (bi-weekly). Moreover, a critical review has to be prepared for 1 of the papers presented.

Objective
On the one hand, participating students are exposed to research at the frontier of international economic policy research. On the other hand, skills such as critical thinking and preparing reviews are learned.

364-0513-00L Empirical Methods in Energy and Environmental Economics

Does not take place this semester.

Abstract
This course is designed for PhD & advanced Masters students who are interested in energy and environmental economics. The focus of the lectures/seminars is on methods of applied econometrics in these fields. The course is composed of lectures on specific topics and a seminar. In the seminar, students will have an opportunity to present own papers or to present and discuss empirical studies.

Objective
The objectives of this course are twofold: first, students will learn about the application of econometric techniques in the fields of energy and environmental economics. Second, through the presentation of their papers or the presentation and discussion of the existing literature, students will also get a sense of how critical thinking can be used to assess empirical research in energy and environmental economics.

Content
Day 1: Thursday, January 9
09:00 – 10:30 Session 1: Multinomial choice, heterogeneity (instructor: Greene)
11:00 – 12:30 Session 2: Multinomial choice, heterogeneity (instructor: Greene)
13:30 – 15:00 Session 3: Latent class and Mixed logit (instructor: Greene)
15:30 – 16:30 Session 3: Latent class and Mixed logit (instructor: Greene)
Day 2: Friday, January 10
08:30 – 10:00 Session 1: Measurement of the energy efficiency (instructor: Filippini)
10:30 – 12:00 Session 2: Structural models (instructor: Houdé)
13:00 – 14:30 Session 3: Student Presentations
15:00 – 16:30 Session 3: Student Presentations
Day 3: Saturday, January 11
08:30 – 09:30 Session 1: Seminar by Prof. Kenneth Gillingham (Yale University)
09:30 – 10:30 Session 1: Seminar by Prof. Beat Hintermann (Basel University)
10:30 – 11:30 Session 1: Seminar by Prof. Matt Kotchen (Yale University)
10:30 – 12:30 Session 2: Student Presentations
13:30 – 15:30 Session 3: Student Presentations

Prerequisites / notice
Lecture notes will be made available to the students.

Students are expected to have attended courses in advanced microeconomics and in econometrics.

363-1136-00L Dynamic Macroeconomics, Innovation and Growth

Students who have successfully completed the course "Dynamic Macroeconomics" (364-0559-00L) or "Economics of Innovation and Growth" (363-0562-01L) can not register for this course.

Abstract
Introducing dynamic models and workhorses in macroeconomics, understanding the role of innovation and institutions for economic development and discussing policies to foster innovation and economic growth, with a perspective on how digitization and artificial intelligence will affect our economies.

Objective
After the course, students will be familiar with dynamic general equilibrium theory and the basic workhorses in macroeconomics. Participants will be able to speak the Arrow-Debreu and recursive language and apply the frameworks to interesting issues, such as innovation and growth. Moreover, students will understand how the world has developed over the last centuries and the proximate and fundamental causes of innovation and economic growth. Students will understand and apply the basic models of economic growth and will be able to identify policies to foster innovation and growth and to reduce the large wealth differences in the world. Finally, they understand how digitization and artificial intelligence will drive the economies.

Content
1. Introduction
2. The Arrow-Debreu Approach and Sequential Markets
3. The Neoclassical Growth Model and the Representative Agent Model (with Mathematical Background)
4. Technological Progress and how the World has developed
5. Innovations and Growth (New Growth Theory)
6. Growth Policies and Fundamental Causes for Growth
7. Digitization and Artificial Intelligence
We discuss research on inequality in different areas of economics. Possible topics include distributional national accounts, heterogeneous returns, inheritances, intergenerational mobility, gender inequality in the labor market (topics will also be decided upon depending on the students' interests). Students will present a paper and critically comment on it (as if they would referee the paper).

After the course, participants will have a solid understanding of the current state of research on inequality in different fields in economics and, starting from there, will be able to develop their own research ideas. They will further learn how to critically assess and referee a paper, as it is common practice during the referee process, and they will practice their presentation skills and give feedback to each other. The students will therefore also acquire competences for conferences and participation in the scientific discourse.

The target group of this course are PhD students who are interested in writing a paper related to economic inequality. Advanced Master students who are interested in taking the course, especially those who plan to pursue a PhD in Economics afterwards, are welcome, too. The topic is intentionally kept broad to leave room for individual research interests and cover different areas. This will allow students to get to know the current state of research in different, but related areas and help them develop their own research question.

By critically examining the literature, students will also learn what makes a well-written paper. By presenting papers, students will further train their presentation skills and we will take time to give feedback in class on the presentations, too. Oral and written presentation of research are both integral parts of a successful academic career. In the written assignment, finally, students will learn how to write a referee report.

The course will start with an introduction into the topic and an overview of inequality research in economics. Inequality has become a buzzword in many paper titles and abstracts, but different areas of economics have sometimes very different approaches to this popular topic. The main part of the course will consist of reading and presenting papers that belong to different areas of economics, including Macroeconomics, Public Economics, and Microeconomics / Labour Economics.

Below you find the suggestive syllabus for this course. I will provide a list of papers in each of the six blocks at the beginning of the semester, and students will choose a paper to present during the semester (suggestions to present a paper that is not on the list are welcome). Students are required to read all papers discussed in the course. At the end of the semester, they will write a referee report with possible suggestions for future research. The written assignment is due in early January.

| 14. Current Literature on Digitization and Artificial Intelligence |
| Prerequisites / notice | Students who have successfully completed the course “Dynamic Macroeconomics” (364-0559-00L) or “Economics of Innovation and Growth” (363-0562-01L) can not register for this course. |

<table>
<thead>
<tr>
<th>Economics of Inequality</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Martinez</td>
<td></td>
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</table>

We discuss research on inequality in different areas of economics. Possible topics include distributional national accounts, heterogeneous returns, inheritances, intergenerational mobility, gender inequality in the labor market (topics will also be decided upon depending on the students' interests). Students will present a paper and critically comment on it (as if they would referee the paper).

After the course, participants will have a solid understanding of the current state of research on inequality in different fields in economics and, starting from there, will be able to develop their own research ideas. They will further learn how to critically assess and referee a paper, as it is common practice during the referee process, and they will practice their presentation skills and give feedback to each other.

The students will therefore also acquire competences for conferences and participation in the scientific discourse.

The target group of this course are PhD students who are interested in writing a paper related to economic inequality. Advanced Master students who are interested in taking the course, especially those who plan to pursue a PhD in Economics afterwards, are welcome, too. The topic is intentionally kept broad to leave room for individual research interests and cover different areas. This will allow students to get to know the current state of research in different, but related areas and help them develop their own research question.

By critically examining the literature, students will also learn what makes a well-written paper. By presenting papers, students will further train their presentation skills and we will take time to give feedback in class on the presentations, too. Oral and written presentation of research are both integral parts of a successful academic career. In the written assignment, finally, students will learn how to write a referee report.

The course will start with an introduction into the topic and an overview of inequality research in economics. Inequality has become a buzzword in many paper titles and abstracts, but different areas of economics have sometimes very different approaches to this popular topic. The main part of the course will consist of reading and presenting papers that belong to different areas of economics, including Macroeconomics, Public Economics, and Microeconomics / Labour Economics.

Below you find the suggestive syllabus for this course. I will provide a list of papers in each of the six blocks at the beginning of the semester, and students will choose a paper to present during the semester (suggestions to present a paper that is not on the list are welcome). Students are required to read all papers discussed in the course. At the end of the semester, they will write a referee report with possible suggestions for future research. The written assignment is due in early January.

<table>
<thead>
<tr>
<th>Syllabus</th>
<th>Aggregate trends in income and wealth inequality</th>
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<tbody>
<tr>
<td>- Top income and wealth shares</td>
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<td>- Distributional national accounts DINA</td>
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<td>- Wealth income ratios</td>
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<tr>
<td>Measurement of top wealth and its difficulties</td>
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<tr>
<td>- Capitalization and heterogeneous returns</td>
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<td>- Tax data and tax evasion</td>
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<tr>
<td>- Alternative data and its limitations</td>
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<tr>
<td>Inheritances</td>
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<td>- Their role for wealth inequality</td>
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<tr>
<td>- Optimal taxation of inheritances</td>
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<td>Intergenerational mobility</td>
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<td>- Measurement</td>
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<tr>
<td>- Exogenous variation and causal identification</td>
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<td>Gender Inequality in the labour market</td>
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<td>- Gender wage gap</td>
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<td>- Child penalties</td>
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<tr>
<td>Pandemics and their effects on inequalities</td>
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<td>- Covid-19</td>
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<td>- 1918 Influenza Pandemic (“Spanish Flu”)</td>
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<td>- The plague</td>
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### Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>364-1064-00L</td>
<td>Inaugural Seminar - Doctoral Retreat</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>U. Renold, A. Bommier, P. Egger, R. Finger, G. Grote</td>
</tr>
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<td></td>
<td>Pre-registration upon invitation required.</td>
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<td>Once your pre-registration has been confirmed, a registration in myStudies is possible.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>This course is geared towards first and second-year doctoral candidates of MTEC. It is held as in a workshop style. Students attending this seminar will benefit from interdisciplinary discussions and insights into current and future work in business and economics research.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>- introduce doctoral candidates to the world of economics, management and systems research at MTEC.</td>
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<td>- make doctoral candidates aware of silo-thinking in the specific sub-disciplines and encourage them to go beyond those silos.</td>
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<td>- discuss current issues with regard to substantive, methodological and theoretical domains of research in the respective fields</td>
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### Transferable Skills

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<tr>
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<th>Lecturers</th>
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<tr>
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<td><strong>Abstract</strong></td>
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</table>
### Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

### Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

#### 900-0106-DRL Transferable Skills Course I (min 4 days)
Only for doctoral students.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### 900-0107-DRL Transferable Skills Course II (min 4 days)
Only for doctoral students.

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<th>Lecturers</th>
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<tbody>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### 900-0108-DRL Transferable Skills Course III (min 4 days)
Only for doctoral students.

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<tbody>
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</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### 900-0109-DRL Transferable Skills Course I (min 4 days, with Poster or Talk)
Only for doctoral students.

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<tr>
<th>Lecturers</th>
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<tbody>
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<td>W</td>
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</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### 900-0110-DRL Transferable Skills Course II (min 4 days, with Poster or Talk)
Only for doctoral students.

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<tbody>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### 900-0111-DRL Transferable Skills Course III (min 4 days, with Poster or Talk)
Only for doctoral students.

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<tr>
<th>Lecturers</th>
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<tbody>
<tr>
<td>W</td>
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</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### 900-0112-DRL Participation in Commission I (min 1 year)
Only for doctoral students.

<table>
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<tr>
<th>Lecturers</th>
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<tbody>
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<td>W</td>
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</table>

Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

#### 900-0113-DRL Participation in Commission II (min 1 year)
Only for doctoral students.

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<tr>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>W</td>
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</tbody>
</table>

Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract: Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective: Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract: Active participation in the presidium or executive board of a university group for at least 1 year.

Objective: Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<td>2K</td>
<td>Lecturers</td>
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</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract: Participation in summer or winter schools with a maximum duration of 3 days.

Objective: Participation in summer or winter schools with a maximum duration of 3 days.

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>Summer School II (1-3 days)</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract: Participation in summer or winter schools with a maximum duration of 3 days.

Objective: Participation in summer or winter schools with a maximum duration of 3 days.

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<th>Number</th>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract: Participation in summer or winter schools with a maximum duration of 3 days.

Objective: Participation in summer or winter schools with a maximum duration of 3 days.

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<th>Number</th>
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<td>900-0153-DRL</td>
<td>Summer School I (1-3 days, with Poster or Talk)</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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Abstract: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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<th>Number</th>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
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<td>Participation in summer or winter schools with a minimum duration of 4 days.</td>
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| 900-0158-DRL | Summer School III (min 4 days)      | W    | 2       | 4K   | Lecturers |
|             | Only for doctoral students.         |      |         |      |           |
|             | Participation in summer or winter schools with a minimum duration of 4 days. |      |         |      |           |
|             | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |      |         |      |           |

| 900-0159-DRL | Summer School I (min 4 days, with Poster or Talk) | W | 3 | 6K | Lecturers |
|             | Only for doctoral students.             |      |         |      |           |
|             | Participation in summer or winter schools with a minimum duration of 4 days. |      |         |      |           |
|             | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |      |         |      |           |

| 900-0160-DRL | Summer School II (min 4 days, with Poster or Talk) | W | 3 | 6K | Lecturers |
|             | Only for doctoral students.               |      |         |      |           |
|             | Participation in summer or winter schools with a minimum duration of 4 days. |      |         |      |           |
|             | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |      |         |      |           |

| 900-0161-DRL | Summer School III (min 4 days, with Poster or Talk) | W | 3 | 6K | Lecturers |
|             | Only for doctoral students.                |      |         |      |           |
|             | Participation in summer or winter schools with a minimum duration of 4 days. |      |         |      |           |
|             | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |      |         |      |           |

| 900-0162-DRL | External Conference I (incl. Poster or Talk) | W | 1 | 2K | Lecturers |
|             | Only for doctoral students.                 |      |         |      |           |
|             | Participation in conferences outside ETH to foster scientific exchange. |      |         |      |           |
|             | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |      |         |      |           |

| 900-0163-DRL | External Conference II (incl. Poster or Talk) | W | 1 | 2K | Lecturers |
|             | Only for doctoral students.                 |      |         |      |           |
|             | Participation in conferences outside ETH to foster scientific exchange. |      |         |      |           |
|             | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |      |         |      |           |

| 900-0164-DRL | External Conference III (incl. Poster or Talk) | W | 1 | 2K | Lecturers |
|             | Only for doctoral students.                 |      |         |      |           |
|             | Participation in conferences outside ETH to foster scientific exchange. |      |         |      |           |
|             | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |      |         |      |           |

Abstract: Participation in summer or winter schools with a minimum duration of 4 days.

Objective: Participation in summer or winter schools with a minimum duration of 4 days.
### Doctorate Management, Technology, and Economics - Key for Type

<table>
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<td>Courses outside the curriculum</td>
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<td>W</td>
<td>Eligible for credits</td>
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<td>Suitable for doctorate</td>
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<td>E-</td>
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### Key for Hours

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<td>colloquium</td>
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<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Doctorate Mechanical and Process Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0107-20L</td>
<td>High Performance Computing for Science and Engineering (HPCSE) I</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
</tbody>
</table>

**Abstract**
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering. With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

**Content**
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

**Lecture notes**
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/

**Literature**
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

**Prerequisites / notice**
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0111-00L</td>
<td>Research Seminar in Fluid Dynamics</td>
<td>E-</td>
<td>0 credits</td>
<td>2S</td>
<td>F. Coletti, P. Jenny, O. Supponen</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Exchange on current internal research projects. Training of presentation skills.

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

**Abstract**

**Objective**

**Content**

**Lecture notes**
Presentations, handouts and instructions are provided for each experiment.

**Literature**

**Prerequisites / notice**
Basic understanding in the following areas:
- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0529-00L</td>
<td>Computational Mechanics II: Nonlinear FEA</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>L. De Lorenzis</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.
1. Introduction: various sources of nonlinearities and implications for FEA.

Lecture notes will be provided. However, students are encouraged to take their own notes.

Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

## 151-0563-01L Dynamic Programming and Optimal Control

**Abstract**
Introduction to Dynamic Programming and Optimal Control.

**Objective**
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

**Literature**

**Prerequisites / notice**
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

## 151-0593-00L Embedded Control Systems

**Abstract**
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

**Objective**
Familiarize students with main architectural principles and concepts of embedded control systems.

**Content**
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

**Lecture notes**
Lecture notes, lab instructions, supplemental material

**Prerequisites / notice**
Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

## 151-0623-00L ETH Zurich Distinguished Seminar in Robotics, Systems and Controls

**Abstract**
This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

**Objective**
Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msri.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.

**Content**
This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be monitored. If for some reason a student cannot attend one of the lectures, the student must select another ETH or University of Zurich seminar related to the field and submit a one page description of the seminar topic. Please see http://www.msri.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a suggestion of other lectures.

**Prerequisites / notice**
Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one page summary of the attended lecture. No exceptions to this rule are allowed.

## 151-1053-00L Thermo- and Fluid Dynamics

**Abstract**
Current advanced research activities in the areas of thermo- and fluid dynamics are presented and discussed, mostly by external speakers.

Knowledge of advanced research in the areas of thermo- and fluid dynamics

## 151-8101-00L International Engineering: from Hubris to Hope

**Abstract**
Since Europe surrendered their colonial assets, engineers from rich countries have returned to the African continent to address the real and perceived ills that they felt technology could solve. And yet, 70 years on, the promise of technology has largely failed to deliver widespread, substantive improvements in the quality of life. Why?

**Objective**
This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.

After completing the course, participants will be able to
- critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world” “developing” “global south” “low and middle-income” and justify their own chosen terminology
- recognize the role of racism and white-supremacy in the development of the Aid industry
- understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
- Debate the merits of international engineering in popular culture and media
- Propose improved SDG indicators that address current shortcomings
- Compare the engineering curricula of different countries to identify relative strengths and shortcomings
- Explain the inherent biases of academic publishing and its impact on engineering failure
- Analyse linkages between the rise of philanthropy and strategic priority areas
- Recommend equitable, just funding models to achieve more sustainable outcomes
- Formulate a vision for the international engineer of the future
Content
Role of international engineering during colonialism
Transition of international engineering following colonialism
White saviourism and racism in international engineering
International engineering in popular culture
The missing role of Engineering Education
Biases in academic publishing
The emerging role in Global Philanthropy
The paradox of International funding

Literature

Scientific Writing for Publication in Engineering

151-9900-00L  Scientific Writing for Publication in Engineering  ■  W  2 credits  1G  P. Maher
Only for D-MAVT doctoral students.
Number of participants limited to 15 per group.
Abstract
Scientific Writing for Publication in Engineering is a short course (5 half-day workshops) designed to help junior researchers develop the skills needed to write their first research articles in English.
Objective
The course deals with topics such as
- Fitting texts to target readerships and journals
- Managing the writing process efficiently
- Structuring each section of the text effectively
- Producing fluent and reader-focused sentences and paragraphs
- Editing the text before submission
- Revising in response to reviewers' comments.
Content
Participants produce a number of short texts as homework assignments and receive detailed individual feedback on these during the course.

Applied Compositional Thinking for Engineers II

151-9905-00L  Applied Compositional Thinking for Engineers II  ■  W  4 credits  3G  A. Censi, J. Lorand
Abstract
This course is an introduction to advanced topics in Applied Category Theory focused on the need of applications. The course favors a computational, constructive, and compositional approach targeted to specific applications in engineering.
Objective
In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of the problem and the design of the solution. However, the problem is that the type of math which could be useful to applications is not traditionally taught. Applied Category Theory is a new field of mathematics that could help thinking about compositionality. However, there exists no easy path for learning it for engineers that is approachable and shows practical applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I), offered in Spring 2021.
This course's goal is not to teach category theory for the sake of it. Rather, we will teach the "compositionality way of thinking": category theory will be just the means towards it. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.

The course will favor a computational/constructive approach, highlighted even more in the second part of the class: each concept is accompanied by concrete exercises in the programming language Python.

Content
Categories

Lecture notes
Slides and notes will be provided.

Literature
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements of an organization on the basis of real cases, and the impacts of misfits between those elements and on the application of a selection of tools and methods.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students. These course materials will form the point of departure for the lectures, class discussions and team work.

By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate routine operations in order to meet evolving customers' and societal needs. The students will achieve these goals by being able to:

- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how change, internally or externally initiated, impact such relationships

The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Algebra (sets, posets, relations, semigroups, groups).
3) Python programming.

We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.

**Prerequisites / notice**

The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Algebra (sets, posets, relations, semigroups, groups).
3) Python programming.

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in Spring Semester are sufficiently proficient in (1)-(3).

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites</th>
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</thead>
<tbody>
<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>3</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
</tr>
<tr>
<td>363-0341-00L</td>
<td>Introduction to Management</td>
<td>3</td>
<td>Z. Zagorac-Uremovic, D. Baschung, J. O'Neil</td>
</tr>
</tbody>
</table>

**Prerequisites**

- We assume this knowledge:
  1. Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
  2. Algebra (sets, posets, relations, semigroups).
  3. Python programming.

**Abstract**

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1) broaden understanding of management principles and frameworks
2) advance insights into the sources of corporate and entrepreneurial success
3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

**Content**

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students. These course materials will form the point of departure for the lectures, class discussions and team work.

**Lecture notes**

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

These course materials will form the point of departure for the lectures, class discussions and team work.

**Taught competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Problem-solving: assessed

- **Social Competencies**
  - Communication: assessed
  - Self-presentation and Social Influence: assessed

- **Personal Competencies**
  - Creative Thinking: assessed
  - Critical Thinking: assessed

**Literature**

The content of the course will rely on different readings and selected chapters of following book:


Selected readings from the book and additional learning materials will be available on the course Moodle:
https://moodle-app2.let.ethz.ch/course/view.php?id=15262

**Prerequisites / notice**

Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on moodle. This preparation is required to participate in the lectures.

The final exam is requested for all types of students (BSc, MSc, MA, PhD, and Exchange students).

It is not possible to retake the exam within the same term or academic year.

We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.
This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

### Concepts and Theories
- Problem-solving
- Decision-making
- Analytical Competencies
- Concepts and Theories

### Social Competencies
- Leadership and Responsibility
- Customer Orientation
- Cooperation and Teamwork

### Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics

This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, guest speakers, simulations and group work.

### Taught competencies
- Subject-specific Competencies: Technology and Innovation Management
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: assessed

- Social Competencies: Leadership and Responsibility: not assessed
  - Customer Orientation: not assessed
  - Cooperation and Teamwork: not assessed

- Personal Competencies: Adaptability and Flexibility: not assessed
  - Critical Thinking: not assessed
  - Integrity and Work Ethics: not assessed

### Literature

### Prerequisites / notice
- The course content and methods are designed for students with some background in management and/or economics.
- The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.
- The course might be taught in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned reading material for self-study.

### Taught competencies
- Subject-specific Competencies: Technology and Innovation Management
  - Concepts and Theories
  - Techniques and Technologies

- Personal Competencies: Critical Thinking

### Literature
- Readings will be available on the Moodle page.
- Slides will be available on the Moodle page.

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**363-0403-00L Introduction to Marketing**

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

### Objective
After taking the class, students will be able to:

1. Define what marketing is and describe its role at different stages of the value chain
2. Apply psychological theories to analyze behavior (e.g., purchase behavior) and identify the needs of (prospective) customers in consumer and business markets
3. Design elements of the marketing mix—e.g., develop new products and set prices—in a way that creates long-term value
4. Create an effective and efficient marketing mix that attracts and engages customers, e.g., by running targeted promotions
5. Use quantitative methods and customer data to manage relationships with customers

### Content
The structure of the course will roughly follow the different steps of the value chain, i.e., the set of activities necessary for offering valuable products to customers. First, it will introduce students to psychological theories that help explain behavior, e.g., purchase behavior. It will also familiarize students with different methods from marketing research, which can be used to identify the needs of customers. Next, the course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing. A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

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

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

### Literature

The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

Objective

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

Content

The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes

Lecture notes, exercises and reference material can be downloaded from Moodle.

The book can also be used for the course 'Principles of Macroeconomics' (Sturm)

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
"Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.


By attending this course, students will be able to:
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

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

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

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

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

By attending this course, students will be able to:
- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

The first part of the course is devoted to financial accounting. It teaches the principles of double-entry accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

This course is a prerequisite for the course Financial Management.

Level: Bachelor


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

Level: Bachelor

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real-life examples and cases.

**Objective**

- 12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...)
- 2h lecture - schedule (±):
  - 15': Introduction
  - 60': (Guest) lecture
  - 15': Discussion related to topic (in groups)
  - 10': Plenary discussion
  - 20': Q&A with (guest) lecturer

**Lecture notes**

- Lecture slides and case material

**Literature**

- A. Koepf

**Prerequisites / notice**

- Basic knowledge in international economics and a good background in macroeconomics.

**Abstract**

- Monetary Policy
- W 3 credits 2V
- J.-E. Sturm. A. Rathke
- The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the things between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real-world issues.
- Content
- For the functioning of today's economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today's major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

**Lecture notes**

- The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17629) contains announcements, course information, and lecture slides.

**Objective**

- This course will introduce the fundamentals of monetary economics and explain the working and impact of monetary policy. The main aim of this course is to describe and analyze the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, and the differences between monetary policy rules and discretionary policy, as well as in institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.

**Content**

- For the functioning of today's economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today’s major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

**Literature**


**Prerequisites / notice**

- Basic knowledge in international economics and a good background in macroeconomics.

**Abstract**

- Applied Analysis of Variance and Experimental Design
- W 5 credits 2V+1U
- L. Meier

**Objective**

- Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**

- Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**


**Prerequisites / notice**

- The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

**Abstract**

- Patents
- W 1 credit 1V
- A. Koepf, P. Pliska
- Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Introduction into intellectual property: prosecution of patent applications; patent information; exploitation and enforcement of patents; peculiarities in pharmaceutics and medicine; social, political, and ethical aspects; Trademarks.
Objective

Basic knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

Content

1. Introduction into industrial property (patents, trademarks, industrial designs);
2. Prosecution of patent applications (patentability);
3. Patent information (patent publications, databases, searches);
4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement);
5. Peculiarities in pharmaceutics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication);
6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions);
7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma-trademarks.

Lecture notes

A script is provided in electronic form during the lecture.

Literature


Prerequisites /

None

Taught

Subject-specific Competencies

- Concepts and Theories

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Synthetic Biology II

Does not take place this semester.

Students in the MSc Biotechnology (Programme Regulations 2017) may select Synthetic Biology II instead of the Research Project 1.

Abstract

7 months biological design project, during which the students are required to give presentations on advanced topics in synthetic biology (specifically genetic circuit design) and then select their own biological system to design. The system is subsequently modeled, analyzed, and experimentally implemented. Results are presented at an international student competition at the MIT (Cambridge).

Objective

The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.

Content

Presentations on advanced synthetic biology topics (e.g. genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence, (DNA synthesis external,) implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (www.igem.org).

Lecture notes

Handouts during course

Prerequisites /

None

The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc.

This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April.

Please note that the number of ECTS credits and the actual work load are disconnected.

Research Ethics

Number of participants limited to 40

Abstract

Students are able to identify and evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective

Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning

1. Ethics - the basics
   1.1 What ethics is not…
   1.2 Recognising an ethical issue (awareness)
   1.3 What is ethics? Personal, cultural and ethical values, principles and norms
   1.4 Ethics: a classification
   1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
   2.1 What is normative ethics?
   2.2 Types of normative theories – three different ways of thinking about ethics:
      Virtue theories, duty-based theories, consequentialist theories
   2.3 The plurality of normative theories (moral pluralism)
   2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
   3.1 How (not) to approach ethical issues
   3.2 What is a moral dilemma? Is there a correct method for answering moral questions?
   3.3 Methods of making ethical decisions

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
   1.1 What is research integrity and why is it important?
   1.2 What is research misconduct?
   1.3 Questionable/Detrimental Research Practice (QRP/DRP)
   1.4 What is the incidence of misconduct?
   1.5 What are the factors that lead to misconduct?
   1.6 Responding to research wrongdoing
   1.7 The process of dealing with misconduct

2. Data Management
   2.1 Data collection and recordkeeping
   2.2 Analysis and selection of data
   2.3 The (mis)representation of data
   2.4 Ownership of data
   2.5 Retention of data
   2.6 Sharing of data (open research data)
   2.7 The ethics of big data

3. Publication ethics / Responsible publishing
   3.1 Background
   3.2 Criteria for being an author
   3.3 Ordering of authors
   3.4 Publication practices

III. Research Ethics – External responsibilities

1. Research involving human subjects
   1.1 History of research with human subjects
   1.2 Basic ethical principles – The Belmont Report
   1.3 Requirements to make clinical research ethical
   1.4 Social value and scientific validity
   1.5 Selection of study participants – the concept of vulnerability
   1.6 Favourable risk-benefit ratio
   1.7 Independent review - Ethics Committees
   1.8 Informed consent
   1.9 Respect for potential and enrolled participants

2. Social responsibility
   2.1 What is social responsibility? a) Social responsibility of the individual scientist
   b) Social responsibility of the scientific community as a whole;
   2.2 Participation in public discussions: a) Debate & Dialogue
   b) Communicating risks & uncertainties
   c) Science and the media
   2.3 Public advocacy (policy making)

3. Dual use research
   3.1 Introduction to Dual use research
   3.2 Case study – Censuring science?
   3.3 Transmission studies for avian flu (H5N1)
   3.4 Synthetic biology

Lecture notes

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice

What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time! connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Taught competencies

Subject-specific Competencies
   Concepts and Theories
   Analytical Competencies
   Decision-making
   Problem-solving

Method-specific Competencies
   Communication
   Cooperation and Teamwork
   Critical Thinking
   Integrity and Work Ethics
   Self-awareness and Self-reflection

Social Competencies
   Creative Thinking
   Communication
   Cooperation and Teamwork

Personal Competencies
   Critical Thinking
   Integrity and Work Ethics
   Self-awareness and Self-reflection

Transferable Skills

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Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>900-0114-DRL</td>
<td>Member of Executive Board (min 1 year)</td>
<td>W</td>
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<td>4P</td>
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<td></td>
<td>Only for doctoral students.</td>
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Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

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<tr>
<td>900-0150-DRL</td>
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Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<td>900-0151-DRL</td>
<td>Summer School II (1-3 days)</td>
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Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.
<table>
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<th>Code</th>
<th>Course Description</th>
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<td>900-0154-DRL</td>
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Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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Doctorate Mechanical and Process Engineering - Key for Type

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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>Compulsory</td>
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Key for Hours

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

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Seminar for Ph.D. students and researchers in the area of metal physics and technology.

K. A. Lewis

Metal Physics and Technology Seminar

Joint Group Seminar

Nanometallurgy

Materials Colloquium

Microscopy Training SEM I - Introduction to SEM

Doctorate Materials Science
Further information at: https://www.ethz.ch/en/doctorate.html

Subject Specialisation

General Subjects

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<td>Polymer Physics</td>
<td>E-</td>
<td>0</td>
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<td>H. C. Öttinger, M. Kröger</td>
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<td>Abstract</td>
<td>Group seminar in polymer physics</td>
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<td>Objective</td>
<td>Continued and deeper education in polymer physics, in particular, for Ph.D. students</td>
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<td>Content</td>
<td>Presentation and discussion of ongoing research projects by members of the polymer physics group and external speakers</td>
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<td>Lecture notes</td>
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<td>J. F. Löffler</td>
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<td>Detailed education of researchers in the area of metallic materials</td>
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<tr>
<td>Content</td>
<td>Presentation and discussion of latest research results concerning basic principles of metals research and development of new metallic materials</td>
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<td>Prerequisites / notice</td>
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<td>- Lectures are generally in English.</td>
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<td>327-0712-00L</td>
<td>Nanometallurgy</td>
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<td>R. Spolenak</td>
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<td>Abstract</td>
<td>Seminar for Ph.D. students and researchers in the area of nanometallurgy</td>
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<tr>
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<td>Joint Group Seminar</td>
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<td>1S</td>
<td>M. Fiebig, N. Spaldin</td>
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<tr>
<td>Abstract</td>
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<td>Objective</td>
<td>Seminar for PhD students and researchers in condensed-matter physics</td>
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<td>Improving the interaction of researchers in the participating groups</td>
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<td>Prerequisites / notice</td>
<td>Presentation and discussion of contemporary research.</td>
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<td>Own scientific contributions</td>
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<td>327-6100-00L</td>
<td>Materials Colloquium</td>
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<td>Professors, further speakers</td>
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<tr>
<td>Abstract</td>
<td>The Materials Colloquium is a platform for PhD students, postdoctoral researchers, group leaders, senior scientists, and professors to present their own and their group’s research to their colleagues. The apero following the colloquium has the purpose to stimulate discussions and to promote networking in a relaxed, more informal environment. The Colloquium is open to all who are interested.</td>
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<tr>
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<td>Learn about recent research in the field of materials science</td>
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<td>Content</td>
<td><a href="https://sam.mat.ethz.ch/mc2022/">https://sam.mat.ethz.ch/mc2022/</a></td>
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<td>327-0721-00L</td>
<td>Writing for Publication in Materials Science</td>
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<td>2</td>
<td>1G</td>
<td>K. A. Lewis</td>
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<tr>
<td>Objective</td>
<td>This short course is designed to help junior researchers in Materials Science develop the skills needed to write their first research articles. The course deals with topics such as</td>
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<td>- identifying target readerships and selecting outlets,</td>
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<td></td>
<td>- managing the writing process efficiently,</td>
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<td>- structuring the text effectively,</td>
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<td>- producing logical flow in sentences and paragraphs,</td>
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<td>- editing the text before submission, and</td>
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<td></td>
<td>- revising the text in response to reviewers’ comments.</td>
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<tr>
<td>Content</td>
<td>Participants will be expected to produce a number of short texts as homework assignments and will receive individual feedback on these during the course. Wherever feasible, elements of participants’ future research articles can be developed as assignments within the course, so it is likely to be particularly useful for those who have their data and are about to begin the writing process.</td>
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<td></td>
<td>Part 1: Introduction to the course; the writing context; identifying target readers and targeting journals; using model texts; activating vocabulary; writing clear English sentences; the English verb system in research publications - using tense, aspect, and voice</td>
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<td>Part 2: The writing process; structural decisions (IMR&amp;D and variations); from plan to draft; basics of paragraph structure; reader-friendly paragraph structure; patterns and tools for creating logical flow; the English noun phrase in research publications</td>
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<td>Part 3: The experimental narrative; process descriptions, explanation and justification; data commentaries; embedding figures, diagrams, etc.</td>
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<td>Part 4: Introductions; creating a research space (CARS); writing about the literature; reference, citation, paraphrase and quotation; discussion and conclusion sections; overview of abstracts and titles</td>
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<td></td>
<td>Part 5: Managing the strength of the claim - hedging and emphasis; punctuation and style; the editing process; responding to reviewers’ comments; preparing writing portfolios for assessment and research articles for submission</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This short course is designed to help junior researchers in Materials Science develop the skills needed to write their first research articles.</td>
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Prerequisites / notice

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTPU.html).
The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective

- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content

During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- Electron sources, electron lenses and probe formation
- Beam/specimen interaction, image formation, image contrast and imaging modes.
- Sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Prerequisites / notice

No mandatory prerequisites.

327-2126-00L  Microscopy Training TEM I - Introduction to TEM

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https:// scopem.ethz.ch/education/ MTP0.html).

All applicants must additionally register on this form: (link will follow)

Abstract

The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

Objective

Understanding of:
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to:
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. bright-field and dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

Content

Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

Prerequisites / notice

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.
Course consists of a few lectures, several tutorials and project-based exercises. Topics include:

- ECTS
- Hours
- Lecturers

The first Introduction Day comprises general and access information, cleanroom basics, infrastructure information, safety training, cleanliness seminar, chemistry seminar and safety test. The introduction day is mandatory for each user who intends to use the FIRST cleanrooms independently of level of experience.

Lecture notes
https://moodle-app2.let.ethz.ch/user/index.php?id=12731

### Advanced Manufacturing (MaP Doctoral School)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>064-0025-22L</td>
<td>Introduction to Computational Research in Architecture, Engineering, Fabrication and Construction</td>
<td>W</td>
<td>2</td>
<td>3K</td>
<td>P. Block</td>
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</tbody>
</table>

**Abstract**
The PhD-level course (primarily for A&T PhDs) will introduce computational methods for architecture, engineering, fabrication & construction, incentivising computational literacy. Students learn the theoretical background and basic implementation details of fundamental data structures and algorithms, and to solve real-world problems using the COMPAS framework and other open-source libraries.

**Objective**
Understand the scope and relevance of computational methods for architecture and engineering research and practice, ii) the theoretical background of fundamental data structures, iii) the basic principles of algorithmic design; iv) implement basic versions of prevalent algorithms related to architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation; v) use sophisticated algorithms available through open-source libraries to solve real-world problems; and, v) use common CAD tools as interfaces to self-implemented solutions.

**Content**
Course consists of a few lectures, several tutorials and project-based exercises. Topics include:
- intro to geometry processing, data structures, topology, numerical computation
- domain-specific case studies (e.g. on architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation)

**Prerequisites / notice**
Priority is given to PhD students.

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<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0139-00L</td>
<td>Scientific Machine and Deep Learning for Design and Construction in Civil Engineering</td>
<td>W</td>
<td>3</td>
<td>4G</td>
<td>M. A. Kraus, D. Griego, R. Rust</td>
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</tbody>
</table>

**Abstract**
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

**Objective**
Upon completion of the course, the students will be able to:
1. understand main ML background theory and methods
2. assess a problem and apply ML and DL in a computational framework accordingly
3. Incorporating scientific domain knowledge in the SciML process
4. Define, Plan, Conduct and Present a SciML project

**Content**
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

**Literature**
A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

**Prerequisites / notice**
Familiarity with MATLAB and / or Python is advised.

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<tr>
<th>Number</th>
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<tr>
<td>101-0167-01L</td>
<td>Fibre Composite Materials in Structural Engineering</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Motavalli</td>
</tr>
</tbody>
</table>

**Abstract**
This course aims to provide graduate level introduction into Machine and especially scientific Machine Learning for applications in the design and construction phases of projects from civil engineering.

**Objective**
At the end of the course, you shall be able to:
1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessray testing and SHM techniques for FRP structures,
3) Continue your education as a phd student in this field.
Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes
Power Point Presentations available online at www.empa.ch/abt303

Literature
3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019

Prerequisites / notice
1) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components
2) Working with Composite Materials (in the Laboratory, application, testing, etc)

102-0357-00L Waste Recycling Technologies W 3 credits 2G R. Bunge

Abstract
Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

Objective
At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

Content
Introduction
Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland

Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
Flow sheet basics: Balancing mass flows
Standard processes: batch vs. continuous
Assessment of separation success: Separation function; grade vs. recovery

Separation Processes
Separation according to size and shape (Classification): Screening, Flow separation
Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology, Froth flotation

Lecture notes
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Literature
A list of recommended books will be provided.

Prerequisites / notice
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

151-0293-00L Combustion and Reactive Processes in Energy and Materials Technology W 4 credits 2V+1U+2A N. Noiray, F. Ernst, C. E. Frouzakis

Abstract
The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials.

Objective
The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials. The lecture is part of the focus "Energy, Flows & Processes" on the Bachelor level and is recommended as a basis for a future Master in the area of energy. It is also a facultative lecture on Master level in Energy Science and Technology and Process Engineering.

Content

Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English

Literature


151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II W 4 credits 3G A. Kunz

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.
Introduction to Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of analytical competencies

The main objectives of this lecture are:

- To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials

Focus is on laminated fibre reinforced polymer composites. The courses treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Variable stiffness structures

The course consists of lectures and exercises.

Lecture notes

The lecture material is covered by the script and further literature is referenced in there.

The handout is available in German and English.

Lecture notes

Script, handouts, exercises and additional material are available in PDF-format on the CMASLab webpage resp on moodle.

https://moodle-app2.let.ethz.ch/course/view.php?id=2610

The course consists of lectures and exercises.

2V+1U

Assessed

Creative Thinking

Assessed

Analytical Competencies

Assessed

Communication

Assessed

Method-specific Competencies

Analytical Competencies

Assessed

Media and Digital Technologies

Assessed

Social Competencies

Communication

Assessed

Cooperation and Teamwork

Assessed

Personal Competencies

Creative Thinking

Assessed

Critical Thinking

Assessed

Subject-specific Competencies

Concepts and Theories

Assessed

Techniques and Technologies

Assessed

Method-specific Competencies

Analytical Competencies

Assessed

Decision-making

Assessed

Media and Digital Technologies

Not assessed

Problem-solving

Assessed

Project Management

Not assessed

Social Competencies

Communication

Not assessed

Cooperation and Teamwork

Not assessed

Customer Orientation

Not assessed

Leadership and Responsibility

Not assessed

Self-presentation and Social Influence

Not assessed

Sensitivity to Diversity

Not assessed

Personal Competencies

Negotiation

Not assessed

Adaptability and Flexibility

Not assessed

Creative Thinking

Assessed

Critical Thinking

Assessed

Integrity and Work Ethics

Assessed

Self-awareness and Self-reflection

Assessed

Self-direction and Self-management

Not assessed

Lecture notes

The handout is available in German and English.

151-0544-00L  Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis

Autumn Semester 2022

W  4 credits  3G

E. Hosseini

An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.
### Content
- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (steels, Ti6Al4V, Inconel, Al alloys),
- Design for additive manufacturing
- Artificial intelligence for AM

Exercise sessions use COMSOL, ANSYS, ABAQUS packages for analysis of MAM processes. Detailed video instructions will be provided to enable students to set up their own simulations. COMSOL, ANSYS and ABAQUS agreed to support the course by providing licenses for the course attendees and therefore the students can install the packages on their own systems.

### Lecture notes
Handouts of the presented slides.

### Literature
No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

### Prerequisites / notice
A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.

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<th>Personal Competencies</th>
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<td>Taught competencies</td>
<td>Concepts and Theories</td>
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<td>Creative Thinking</td>
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<td>Taught competencies</td>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Critical Thinking</td>
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<th>ECTS</th>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>151-0623-00L</td>
<td>ETH Zurich Distinguished Seminar in Robotics, Systems and Controls</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>B. Nelson, M. Hutter, R. Katzschmann, R. Rienner, R. Siegwart</td>
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<tr>
<td>151-0703-00L</td>
<td>Operational Simulation of Production Lines</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>P. Acél</td>
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<tr>
<td>151-0717-00L</td>
<td>Mechanical Production: Assembly, Joining and</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>K. Wegener, V. H. Derflinger</td>
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</table>
Selected topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods. Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures.

K. Wegener

Colloquium on Manufacturing Technology

The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, ro extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.

Note: The previous course title until HS21 "Forming Technology III - Forming Processes".

151-0719-00L Quality of Machine Tools - Dynamics and Metrology at W 4 credits 2V+1U A. Günther, D. Spescha

Abstract

The course "Machine tool metrology" deals with the principal design of machine tools, their spindles and linear axes, with possible geometric, kinematic, thermal and dynamic errors of machine tools and testing these errors, with the influence of errors on the workpiece (error budgeting), with testing of drives and numerical control, as well as with checking the machine tool capability.

Objective

Knowledge of - principal design of machine tools - errors of linear and rotational axes and of machine tools, - influence of errors on the workpiece (error budgeting) - dynamics of mechanical systems - measurement data acquisition / digital signal analysis - experimental modal analysis - geometric, kinematic, thermal, dynamic testing of machine tools - test uncertainty - machine tool capability

Content

Metrology for production, machine tool metrology - basics, like principal machine tool design and machine tool coordinate system - principal design and errors of linear and rotational axes - error budgeting, influence of machine errors on the workpiece - geometric and kinematic testing of machine tools - reversal measurement techniques, multi-dimensional machine tool metrology - thermal influences on machine tools and testing these influences - test uncertainty, simulation - basic concepts of dynamics of mechanical systems and vibration theory - sensors and excitation systems - mode fitting, experimental modal analysis - testing of drives and numerical control - machine tool capability

151-0727-00L Colloquium on Manufacturing Technology W 4 credits 2.5K K. Wegener, A. Kunz

Abstract

Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures, by the majority by experts from the industry. The students prepare a summary of the lectures given and prepare themselves on the basis of these lectures and own information search.

Objective

Continuous further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

Content

Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

151-0729-00L Welding Technology W 4 credits 3G K. Wegener

Abstract

The course provides a survey over the mostly used welding technologies and a basic metallurgical understanding for planning and realization of welded joints.

Objective

The students will gain the competence and understanding to select welding processes properly, to specify the seam preparation and to predict the achievable welding results.

Content

The course presents in some detail the welding processes gas welding, TIG, MIG/MAG, Fillwire welding arc welding and laser welding. After the presentation of the basics of welding the special properties of the different process technologies are explained and the energy sources and the interaction between the process energy and the material discussed. The metallurgical basics to answer material problems are presented. From this process parameters can then be derived, to achieve the desired seam qualities.

Lecture notes

Exercises in the laboratories and with the machine tools of the institute for machine tools and manufacturing (IWF) provide the practical background for this course.

151-0733-00L Basics and Processes of Metal Forming W 4 credits 2V+2U M. Bambach

Abstract

The lecture teaches on the basic knowledge of major processes in sheet metal, tube and bulk metal forming technologies. In particular it focuses on fundamental computation methods, which allow a fast assessment of process behaviour and a rough layout. Process-specific states of stress and deformation are analysed and process limits are identified.

Objective

Acquaintance with forming processes. Determination of forming processes. Interpretation of forming manufacturing

Content

The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, ro extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.
Abstract
Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

Objective
The goal of the lecture is to provide the students with the fundamentals of the nonlinear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:
- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

Content
- introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

Lecture notes
Lecture slides

Literature

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151-3209-00L  Engineering Design Optimization  W  4 credits  4G  K. Shea, T. Stankovic

Number of participants limited to 60.

Abstract
The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them.

Objective
The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.

Content
1. Optimization modeling and theory
2. Unconstrained optimization methods
3. Constrained optimization methods
4. Direct search methods
5. Stochastic and evolutionary search methods
6. Multi-objective optimization

Lecture notes
available on Moodle

Literature

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151-3215-00L  Design for Additive Manufacturing  W  4 credits  2G  M. Meboldt, J. Ferchow

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchowj@ethz.ch).

Abstract
This course focuses on the design, fabrication, and testing of components produced by additive manufacturing (AM) technologies. The course includes a project based on a real-world problem in which students design, fabricate and iteratively optimize functional AM parts using an appropriate AM technology.

Objective
In this course fundamental knowledge of Design for Additive Manufacturing (AM). The course will prepare the students to:
- Apply fundamental AM processes (metal and plastics)
- Apply the AM design guidelines
- Adopt AM in an industrial environment
- Apply design tools and methods in AM
- Create an added value of AM
- Work in a project-based product development team

Content
Parallel to the lectures the students design, manufacture and test prototypes in a project in different product development stages. The course is addressing the following topics:
- State of the art AM Processes for metal and plastics (LPBF, BJ, MJF, SLS, FDM)
- Design guidelines in AM
- Industrial adoption of AM
- Value creation and business models for AM
- Design tools and methods for AM
- Quality management in AM
- Industry cases of AM applications
- Problem solving and creativity
- Agile Development

Lecture notes
Script and handouts are available in PDF-format.
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

### Analytical Competencies

- Students can apply key concepts of POM to detail an operations strategy.
- Students can do simple forecasting of demand and plan the needed capacity to meet it.
- Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
- Students can choose IT, OT, and automation technology for manufacturing applications.
- Students can design information flows, manage master data, and use it to plan and control a factory.
- Students can design material flows in and beyond factories.
- Students can design performance management systems.
- Students can select and use problem-solving tools to improve quality and productivity.
- Additional skills: Students acquire experience in teamwork.

### Production and Operations Management

This course is for master's students.

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchow@ethz.ch).

The successful completion of the course requires active participation in the project, the lecture and the oral exam.

Final grades are based on the performance in the projects, the oral examination and the performance and the participation in the lecture.

### Literature

- Christoph Klahn; Mirko Meboldt: Entwicklung und Konstruktion für die Additive Fertigung - Grundlagen und Methoden für den Einsatz in industriellen Endkundenprodukten Vogel Business Media, Würzburg ISBN: 978-3-8343-3395-7

### Taught competencies

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

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**Laser for Micro- and Nanostructuring**

<table>
<thead>
<tr>
<th>529-0455-00L</th>
<th>Laser for Micro- and Nanostructuring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as microolithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.</td>
</tr>
<tr>
<td><strong>Teaching group</strong></td>
<td>W 2 credits, 2V</td>
</tr>
<tr>
<td><strong>Lecturer</strong></td>
<td>T. Lippert, N. Shepelin</td>
</tr>
</tbody>
</table>

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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 741 of 2345
Objective
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano structuring. Several applications which are still in the research state, e.g. non-optical lithographies, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Content
Introduction to lasers, Overview of micro- and nanotechnology, micro lithography, photoresists: classical types and new developments, laser cutting and welding, laser cleaning, laser ablation, polymer ablation: designed polymers, lasers and surfaces, laser spectroscopy, laser chemical vapor deposition, pulsed laser deposition (PLD), special materials by PLD, alternative structuring methods.

Lecture notes
The script (a copy of the slides) will be handed out during the first lecture.

Literature
FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.

Taught competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies not assessed
- Decision-making not assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

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

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

529-0619-01L Chemical Product Design
Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

Abstract
The 'Chemical Product Design' course teaches students quantitative concepts to analyze, select and transform theoretical concepts from chemistry and engineering into valuable real-world products. Basic chemistry and chemical engineering knowledge is required (Diffusion, Thermodynamics, Kinetics,...).

Objective
This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g. responsive building materials; personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or compound, and the necessary steps to pursue the resulting project within an entrepreneurial environment. We therefore extend the questions of process design (how do we make something?) to the question of what should we make?

Content
Part A: The 'Chemical Product Design' course starts with discussing questions along, What is a chemical product, and why do people pay for it? How does a given compound in a specific setting provide a service? We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

Students are expected to actively develop chemical products along the course. Contributions will be made individually, or in small groups, where a larger topic is studied.

Literature


Prerequisites / notice
Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

Science & Technology of the Small (MaP Doctoral School)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0409-00L</td>
<td>Multiphysics Modeling and Simulation</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>C. I. Roman</td>
</tr>
</tbody>
</table>

Abstract
This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.
As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has it price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

### Lecture notes

Lecture handouts will be posted online.

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
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<th>assessed</th>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<td>Project Management</td>
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<td></td>
<td>Self-direction and Self-management</td>
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<td>assessed</td>
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</table>

### 151-0509-00L 

**Acoustics in Fluid Media: From Robotics to Additive Manufacturing**

*Note: The previous course title until HS21 “Microscale Acoustofluidics”*

**Abstract**

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics. Acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices will be covered.

**Objective**

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

**Content**

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices.

**Lecture notes**


**Prerequisites / notice**

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and homework.

### 151-0604-00L 

**Microrobotics**

*W 4 credits 3G D. Ahmed*

**Abstract**

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics. Acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices will be covered.

**Objective**

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

**Content**

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices.

**Lecture notes**


**Prerequisites / notice**

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and homework.
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are embedded.

Familiarize students with basic science and engineering principles governing the nano domain.

Nanosystems
Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and microfluidic devices.

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

The lecture will be taught in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Format</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0605-00L</td>
<td>Nanosystems</td>
<td>W 4 credits 4G A. Stemmer</td>
<td>Abstract</td>
<td>From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.</td>
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<td></td>
<td>Objective</td>
<td>Familiarize students with basic science and engineering principles governing the nano domain.</td>
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<tr>
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<td>Content</td>
<td>Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled. Topics are treated in 2 blocks: (I) From Quantum to Continuum From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. (II) Interaction Forces on the Micro and Nano Scale Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures.</td>
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<td></td>
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<td>Prerequisites / notice</td>
<td>Course format: Lectures and Mini-Review presentations: Thursday 10-13. Homework: Mini-Review (compulsory continuous performance assessment) Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.</td>
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</tbody>
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<table>
<thead>
<tr>
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<th>Credits</th>
<th>Format</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0620-00L</td>
<td>Embedded MEMS Lab</td>
<td>W 5 credits 3P C. Hierold, M. Haluska</td>
<td>Abstract</td>
<td>Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Objective</td>
<td>Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Content</td>
<td>With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out: Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures Packaging and electrical connection of a MEMS device Testing and characterization of the MEMS device Written documentation and evaluation of the entire production, processing and characterization</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lecture notes</td>
<td>A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Literature</td>
<td>The document provides sufficient information for the participants to successfully participate in the course.</td>
</tr>
</tbody>
</table>
This course aims to familiarize motivated M/BSc students with some of the basic phenomena of particles at the nanoscale, thereby providing guidance throughout the course. Lectures include some of the following:

- Overview & Project Presentation
- Particle Size Distribution
- Particle Diffusion
- Coagulation
- Agglomeration & Coalescence
- Particle Growth by Condensation
- Control of particle size & structure during gas-phase synthesis
- Multi-scale design of aerosol synthesis of particles
- Particle Characterization
- Aerosol manufacture of nanoparticles
- Forces acting on Single Particles in a Flow Field
- Fixed and Fluidized Beds
- Separations of Solid-Liquid & Solid-Gas systems
- Emulsions/droplet formation/microfluidics
- Gas Sensors
- Coaching for proposal & report writing as well as oral presentations

Participating students are required to attend all scheduled lectures and meetings of the course. Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course. For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.
Prerequisites / notice
FluidMechanik I, Thermodynamik I&II & "clean" 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As exceptional effort will be required! Having seen "Chasing Mavericks" (2012) by Apted & Henson, "Unbroken" (2014) by Angelina Jolie and, in particular, "The Salt of the Earth" (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).

151-0913-00L Introduction to Photonics W 4 credits 2V+2U R. Quidant, J. Ortega Arroyo
Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practice. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.

Content
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics I, Physics II

227-0053-00L High-Frequency Design Techniques W 4 credits 2V+2U C. Bolognesi
Abstract
Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective
Introduction to wireless, radio spectrum, review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, antenna basics.

Lecture notes
Lecture notes
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer; Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

**Literature**


Supplementary material will be uploaded in Moodle.
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

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

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

227-0615-00L Simulation of Photovoltaic Devices - From Materials to Modules

W 3 credits 2G

U. Aeberhard

Abstract
The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules and large scale photovoltaic systems.

Objective
Get an overview over the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to predict the performance of solar cells and modules.

Content
- Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)

Literature
- M. A. Green, „Solar cells: operating principles, technology, and system applications”, Prentice Hall, 1982.

Prerequisites / notice
Undergraduate physics, mathematics, semiconductor devices

227-0663-00L Nano-Optics

W 6 credits 2V+2U

M. Frimmer

Abstract
Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Objective
Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.
Content

We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

Prerequisites / notice

- Electromagnetic fields and waves (or equivalent)
- Physics I+II

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<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>227-1635-00L</td>
<td>Electric Circuits</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Shchetinin</td>
</tr>
<tr>
<td>327-0505-00L</td>
<td>Surfaces, Interfaces and their Applications I</td>
<td>W</td>
<td>3</td>
<td>2V+1U</td>
<td>N. Spencer, M. P. Heuberger, L. Isa</td>
</tr>
<tr>
<td>327-0703-00L</td>
<td>Electron Microscopy in Material Science</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze</td>
</tr>
</tbody>
</table>

Abstract

**227-1635-00L**

Students without a background in Electrical Engineering must take "Electric Circuits" before taking "Introduction to Electric Power Transmission: System & Technology".

**227-0505-00L**

After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

**327-0703-00L**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Objective

**227-1635-00L**

At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyse simple electric circuits with RLC elements, apply circuit theorems to simple meshed circuits, analyze AC circuits in a steady state and understand the connection of the explained principles to the modelling of the 3-phase electric power systems.

**227-0505-00L**

To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

**327-0703-00L**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content

**227-1635-00L**

Course will introduce electric circuits variables, circuit elements (resistive, inductive, capacitive), resistive circuits and theorems (Kirchhoff's laws, Norton and Thevenin equivalents), nodal and mesh analysis, superposition principle; it will continue by discussing the complete response circuits (RLC), sinusoidal analysis – ac steady state (complex power, reactive, active power) and conclude with the introduction to 3-phase analysis;

Mathematical foundations of the circuit analysis, such as matrix operations and complex numbers will be briefly reviewed.

This course is targeting students who have no prior background in electrical engineering.

**227-0505-00L**

Introduction to Surface Science

Physical Structure of Surfaces

Surface Forces (static and dynamic)

Adsorbates on Surfaces

Surface Thermodynamics and Kinetics

The Solid-Liquid Interface

Electron Spectroscopy

Vibrational Spectroscopy on Surfaces

Scanning Probe Microscopy

Introduction to Tribology

Introduction to Corrosion Science

**327-0703-00L**

This course is intended for students outside of D-ITET. No prior course in electrical engineering is required.

Lecture notes

**227-1635-00L**

lecture and exercises slides will be distributed after each lecture via moodle platform; additional materials to be accessed online (wileyplus)

**227-0505-00L**

Script Download:

https://moodle-app2.let.ethz.ch/course/view.php?id=17455

**327-0703-00L**

Script Download:

https://moodle-app2.let.ethz.ch/course/view.php?id=17455


Lecture notes / Literature

**227-1635-00L**

Richard C. Dorf, James A. Svoboda

Introduction to Electric Circuits, 9th Edition

Online materials: https://www.wileyplus.com/

Lecture slides and exercises slides

**227-0505-00L**

Chemistry:

General undergraduate chemistry

including basic chemical kinetics and thermodynamics

Physics:

General undergraduate physics

including basic theory of diffraction and basic knowledge of crystal structures

Taught competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Problem-solving

Personal Competencies

Creative Thinking

Critical Thinking

Prerequisites / notice

327-0703-00L

This course will be distributed in English

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Autumn Semester 2022

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In this course we study how the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions.

**Objective**

- Electronic properties and band theory description of conventional solids
- Electronic-lattice coupling and its consequences in functional materials
- Electron-spin/orbit coupling and its consequences in functional materials
- Structure/property relationships in strongly-correlated materials

**Content**

In this course we study how the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions. We begin with a review of the successes of band theory in describing many properties of metals, semiconductors and insulators, and we practise building up band structures from atoms and describing the resulting properties. Then we explore classes of systems in which the coupling between the electrons and the lattice is so strong that it drives structural distortions such as Peierls instabilities, Jahn-Teller distortions, and ferroelectric transitions. Next, we move on to strong couplings between electronic charge and spin-and/or orbital-angular momentum, yielding materials with novel magnetic properties. We end with examples of the complete breakdown of single-particle band theory in so-called strongly correlated materials, which comprise for example heavy-fermion materials, frustrated magnets, materials with unusual metal-insulator transitions and the high-temperature superconductors.

**Lecture notes**

An electronic script for the course is provided in Moodle.

**Handouts**

Hand-outs with additional reading will be made available during the course and posted on the moodle page accessible through MyStudies.

**Prerequisites**

- Statistical Thermodynamics (327-0315-00)
- Quantummechanik für Materialwissenschaftler/innen (327-0316-00)
- Festkörpertheorie für Materialwissenschaftler/innen (327-0416-00)
- Electronic, Optical and Magnetic Properties of Materials (327-0512-00)

or equivalent classes from another institution

**Objective**

The aim is a) to learn how to design and create objects as building blocks with a particular composition, size and shape, b) to understand the chemistry that allows for the creation of such hard and soft objects, and c) to master the concepts to assemble these objects into materials over several length scales.

**Content**

The course is divided into two parts: I) synthesis of 0-, 1-, 2-, and 3-dimensional building blocks with a length scale from nm to μm, and II) assembly of these building blocks into 1-, 2- and 3-dimensional structures over several length scales up to cm. In part I, various methodologies for the synthesis of the building blocks will be discussed, including Turkevich and Brust-Schiffrin-method for gold nanoparticles, hot-injection for semiconducting quantum dots, aqueous and nonaqueous sol-gel chemistry for metal oxides, or gas- and liquid-phase routes to carbon nanostructures. Part II is focused on self- and directed assembly methods that can be used to create higher order architectures from those building blocks connecting the microscopic with the macroscopic world. Examples include photonic crystals, nanocrystal solids, colloidal molecules, mesocrystals or particle-based foams and aerogels.

**Lecture notes**

References to original articles and reviews for further reading will be provided on the lecture notes.

**Prerequisites**

1) Materialsynthesis II (327-0412-00)
2) Kristallographie (327-0104-00L), in particular structure of crystalline solids
3) Materials Characterization II (327-0413-00)

**Objective**

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

**Content**

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

**Objective**

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

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**Content**

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

**Objective**

The course presents the currently most efficient experimental techniques for microstructure material characterization: X-ray diffraction (XRD) and transmission electron microscopy (TEM). The theoretical basics, instrumentation, complementarity and exclusivity of both techniques will be taught. The course includes practical elements and examples of current research projects at D-MATL.
Objective

Students are able to do:
- systematically characterise the microstructure and phases of a given material with X-rays and electrons
- select the right tool (source, instrument, measurement strategy) and design a workflow for solving a microstructure or phase analysis problem
- describe possibilities and limitations of a given characterisation method
- comprehensively store experimentally collected data in a repository following modern data management rules such that data can be evaluated by students not involved in the experiment
- qualitatively and quantitatively evaluate and present experimental data and results collected by others

Content

The main objective of this hands-on practical course is to give students a comprehensive insight into the most important aspects of microstructure characterization using electron and X-ray scattering. The focus is on the complementarity and exclusivity of the two techniques. We will introduce the most important material characterization tasks, present the relevant physical and crystallographic fundamentals, and discuss how the tasks can be solved with electron and X-ray scattering. We will discuss intrinsic and extrinsic advantages and limitations of the methods and explain essential instrumentation requirements specific to each setup. Another essential facet of the course is the link to everyday D-MATL project problems presented by the lecturers or researchers from D-MATL. The lecture is accompanied by hands-on experiments on samples of D-MATL projects using state-of-the-art instruments.

Literature


Prerequisites / notice

Crystallography, X-ray diffraction and electron microscopy on the BSc level. All enrolled students are initially placed on the "waitlist" until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.

Taught competencies

Objective

The main objective of this course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

Content

Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R6, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 205 electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices
Abstract
This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective
Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing

Content
1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
   3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
   4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes
https://moodle-app2.let.ethz.ch/course/view.php?id=

Prerequisites / notice
The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

402-0402-00L Ultrafast Laser Physics

<table>
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<tr>
<th>Objective</th>
<th>Abstract</th>
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<tbody>
<tr>
<td>Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.</td>
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<table>
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<tr>
<td>Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.</td>
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<table>
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<table>
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<th>Prerequisites / notice</th>
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<tr>
<td>Prerequisites: Basic knowledge of quantum electronics (e. g., 402-0275-00L Quantenelektronik).</td>
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<th>Taught competencies</th>
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<tr>
<td>Subject-specific Competencies</td>
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Mostly the original articles, other useful reading can be found in:

Text-books:
A. Imamoglu
G. Scalari

After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview of state of the art experimental techniques used to study fast processes.

Lecture notes
Selected book chapters will be distributed.

Literature
Text-books:
- G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
- R. Loudon, The Quantum Theory of Light
- Atomic Physics, Christopher J. Foot
- Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
- C. Cohen-Tannoudji et al., Atom-Photon-Interactions
- M. Scully and M.S. Zubairy, Quantum Optics
- Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist , published by Oxford University Press.

Based on today's most advanced solid state platform for quantum control, the students will learn how to engineer quantum coherent devices and how to use them to process quantum information. The students will acquire both analytical and numerical methods to model the properties and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.

All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these material, enabled the rich physics and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

Recent advances in atomic physics, such as the development of the "quantum dot" system, has led to a new era of quantum technology. In this course, we will explore the rich physics of these systems and how they can be used to process quantum information.

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

 Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview of state of the art experimental techniques used to study fast processes.

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

402-0452-00L Ultrafast Processes in Solids

Objective
After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview of state of the art experimental techniques used to study fast processes.

Content
Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

Lecture notes
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum electronics.

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Autumn Semester 2022
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1. Experimental techniques, an overview

2. Dynamics of the electron gas
   2.1 First experiments on electron dynamics and lattice heating
   2.2 The finite lifetime of excited states
   2.3 Detection of lifetime effects
   2.4 Dynamical properties of reactions and adsorbents

3. Dynamics of the lattice
   3.1 Phonons
   3.2 Non-thermal melting

4. Dynamics of the spin system
   4.1 Laser induced ultrafast demagnetization
   4.2 Ultrafast spin currents generated by lasers
   4.3 Landau-Lifschitz-Dynamics
   4.4 Laser induced switching

5. Correlated materials

Introduction to Magnetism

Learning material will be made available through a dedicated RStudioServer and through Moodle.

1. Experimental techniques, an overview

2. Semiconductor Nanostructures

   Abstract
   The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

   Objective
   At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
   1. The integer quantum Hall effect
   2. Conductance quantization in quantum point contacts
   3. the Aharonov-Bohm effect
   4. Coulomb blockade in quantum dots

   Content
   1. Introduction and overview
   2. Semiconductor crystals: Fabrication and molecular beam epitaxy
   3. Band structures of semiconductors
   4. k-p-theory, effective mass, envelope functions
   5. Heterostructures and band engineering, doping
   6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
   7. Heterostructures and two-dimensional electron gases
   8. Drude Transport and scattering mechanisms
   9. Single- and bilayer graphene
   10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
   11. Interference effects in Aharonov-Bohm rings
   12. Electron in a magnetic field, Shubnikov-de Haas effect
   13. Integer quantum Hall effect
   14. Coulomb blockade and quantum dots

   Lecture notes

   Literature
   In addition to the lecture notes, the following supplementary books can be recommended:

   Prerequisites / notice
   The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Prerequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book “Spin Dynamics” by Malcolm Levitt.

Lecture notes
A script which covers the topics will be distributed in the lecture and will be accessible through the course Moodle.

529-0455-00L  Laser for Micro- and Nanostructuring
W  2 credits  2V  T. Lippert, N. Shepelin

Abstract
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding.

Objective
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding.

Content
Introduction to lasers. Overview of micro- and nanotechnology. Micro lithography, photoresists: classical types and new developments, laser cutting and welding, laser cleaning, laser ablation, polymer ablation: designed polymers, lasers and surfaces, laser spectroscopy, laser chemical vapor deposition, pulsed laser deposition (PLD), special materials by PLD, alternative structuring methods.

Lecture notes
The script (a copy of the slides) will be handed out during the first lecture.

Literature
FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.
Handouts in English

Handouts will be provided during lecture, T. Bucheli, D. Mitrano


Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

The information on the web can be updated until the beginning of the semester.

Anthropogenic Particles in the Environment

The lecture provides an overview on the behavior and effects of anthropogenic particles in the environment, covering engineered nanoparticles, micro/nanoplastics, tire wear, soot and pigments. The course will cover key concepts of particle behavior and analysis, fate in technical and natural systems, toxicity and environmental risk assessment and sustainability aspects and regulation.

- Definitions, particle types
- Particle behavior: colloidal behavior, transport, transformation
- Sources and release: Material flow modeling
- Fundamentals of particle analysis
- Release and emission
- Fate in the environment: water, soil, air
- Fate in technical systems: water treatment, waste incineration
- Uptake and toxicity of particles
- Environmental risk assessment
- Life cycle assessment

Soft Materials (MaP Doctoral School)

Fluid Dynamics with the Lattice Boltzmann Method

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student’s choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.

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The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; flows with phase transitions.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0524-00L Continuum Mechanics I  W  4 credits  2V+1U A. E. Ehret
Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.
Objective
Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments
Content
Lecture notes
yes

227-0393-10L Bioelectronics and Biosensors  W  6 credits  2V+2U J. Vörös, M. F. Yanik
Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.
Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field
Content

L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

327-0505-00L Surfaces, Interfaces and their Applications I W 3 credits 2V+1U N. Spencer, M. P. Heuberger, L. Isa

Abstract
After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

Objective
To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

Content
Introduction to Surface Science
Physical Structure of Surfaces
Surface Forces (static and dynamic)
Adsorbates on Surfaces
Surface Thermodynamics and Kinetics
The Solid-Liquid Interface
Electron Spectroscopy
Vibrational Spectroscopy on Surfaces
Scanning Probe Microscopy
Introduction to Tribology
Introduction to Corrosion Science

Lecture notes
Script Download:
https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature
Script Download:
https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Prerequisites / notice
Chemistry:
General undergraduate chemistry including basic chemical kinetics and thermodynamics

Physics:
General undergraduate physics including basic theory of diffraction and basic knowledge of crystal structures

Taught competencies

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

| Analytical Competencies | assessed |
| Decision-making         | assessed |

Problem-solving

| Creative Thinking | assessed |
| Critical Thinking  | assessed |

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-1201-00L</td>
<td>Transport Phenomena I</td>
<td>W 5</td>
<td>4G</td>
<td>J. Vermant</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.</td>
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<td></td>
<td>Objective</td>
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</table>
|             | The teaching goals of this course are on five different levels:  
|             | (1) Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling;  
|             | (2) Ability to use the fundamental concepts in applications  
|             | (3) Insight into the role of boundary conditions (mainly part 2)  
|             | (4) Knowledge of a number of applications.  
|             | (5) Flavor of numerical techniques: finite elements and finite differences. |
|             | Content                                          |         |      |             |
|             | Part 1 Approach to Transport Phenomena  
Balance Equations  
Forces and Fluxes  
Applications  
1. Measuring Transport Coefficients  
2. Fluid mechanics  
3. combined heat and flow |
|             | Lecture notes                                    |         |      |             |
|             | Literature                                       |         |      |             |
|             | Prerequisites / notice                            |         |      |             |
|             | Taught competencies                              |         |      |             |
|             | Subject-specific Competencies                     |         |      |             |
|             | Concepts and Theories                             |         |      |             |
|             | Techniques and Technologies                       |         |      |             |
|             | Method-specific Competencies                      |         |      |             |
|             | Problem-solving                                  |         |      |             |
|             | Taught competencies                              |         |      |             |
|             | ankles                                           | assessed|      |             |
|             | knees                                            | assessed|      |             |
|             | Lecture notes                                    |         |      |             |
|             | Literature                                       |         |      |             |

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<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Type</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-1207-00L</td>
<td>Engineering with Soft Materials</td>
<td>W 5</td>
<td>4G</td>
<td>J. Vermant, L. Isa</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>In this course the engineering with soft materials is discussed. First, scaling principles to design structural and functional properties are introduced a. Second, the characterisation techniques to interrogate the structure property relations are introduced, which include rheology, advanced optical microscopies, static and dynamic scattering and techniques for liquid interfaces.</td>
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<td>Objective</td>
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<tr>
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<td>The learning goals of the course are to introduce the students to soft matter and its technological applications, to see how the structure property relations depend on fundamental formulation properties and processing steps. Students should also be able to select a measurement technique to evaluate the properties.</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<tr>
<td></td>
<td>slides with text notes accompanying each slide are presented.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Type</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-1221-00L</td>
<td>Biological and Bio-Inspired Materials</td>
<td>W 4</td>
<td>3G</td>
<td>A. R. Studart, I. Burgert, R. Nicolosi Libanori, G. Panzarasa</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The course first offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials. Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.</td>
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<tr>
<td></td>
<td>Content</td>
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</tbody>
</table>
|             | This course is structured in 3 blocks:  
Block (I): Fundamentals of engineering in biological materials  
- Biological engineering principles  
- Basic building blocks found in biological materials  
Block (II): Replicating biological design principles in synthetic materials  
- Biological and bio-inspired materials: polymer-reinforced and ceramic-toughened composites  
- Lightweight biological and bio-inspired materials  
- Functional biological and bio-inspired materials: surfaces, self-healing and adaptive materials  
Block (III): Bio-inspired design and systems  
- Mechanical actuation - plant systems  
- Bio-inspiration in the built environment |
|             | Lecture notes                                    |         |      |             |
|             | Copies of the slides will be made available for download before each lecture. |
|             | Literature                                       |         |      |             |
|             | The course is mainly based on the books listed below. Additional references will be provided during the lectures. |

### Taught competencies

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

### 327-2227-00L Machine Learning (MaP Doctoral School)  

**Number of participants limited to 15.**

**Objective**  
This course, aimed at doctoral students, has the goal to guide attendees through a progression from basic machine learning (ML) methods, through the extension of those to increasingly complex analyses all the way to the offering of the students the possibility to directly apply the concepts learned during the course to their own data.

**Content**  
The course will combine lectures with hands-on exercises in concentrated blocks across the semester. Students have the possibility to select different blocks, for instance if they already have basic ML programming knowledge. The students will also be able to work on a project related to their research where they apply ML to some imaging data.

**Prerequisites / notice**  
Basic programming knowledge in Python is required.

### 327-6200-00L Reactivity in Micelles and Vesicles  

**Abstract**  
Microscopy images, irrespective of the specific imaging technique, e.g. optical, electron or atomic force microscopy, are an extremely rich source of quantitative data. With the ever increasing push to enhance spatial and temporal resolution, as well as with the increase of storage and computing power, very large amounts of data are easily generated and require automation for data extraction. From this point of view, machine learning (ML) methods, will be an important tool.

**Objective**  
Discussion of different aspects of the chemical reactivity in micelles and vesicles (liposomes) as polymolecular compartments.

**Content**  
With a few selected recent examples, properties of micelles and vesicles will be discussed with the respect to applications as reaction compartments.

**Lecture notes**  
No script.

### 376-0021-00L Materials and Mechanics in Medicine  

**Abstract**  
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Objective**  
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Content**  
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

**Lecture notes**  
Course website on Moodle

**Literature**  
Introduction to Biomedical Engineering, 3rd Edition 2011, Author: John Enderle, Joseph Bronzino, ISBN 9780123749796
Academic Press

### 376-1103-00L Frontiers in Nanotechnology  

**Abstract**  
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

**Objective**  
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

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Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Credits</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1351-00L</td>
<td>Micro/Nanotechnology and Microfluidics for Biomedical Applications</td>
<td>2</td>
<td>2V</td>
<td>E. Delamarche</td>
</tr>
<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>4</td>
<td>3V</td>
<td>K. Maniura, M. Rottmar, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

**Abstract**

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

**Objective**

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETH2/IBM Nanotech Center infrastructure if needed.

**Content**

Mostly formal lectures (2 x 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:

- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photons, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yüksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

**Abstract**

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**

Handouts are deposited online (moodle).

**Literature**


(available online via ETH library)

**Abstract**

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Objective**

Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

**Content**

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Lecture notes**

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

**Literature**

See: www.csms.ethz.ch/education/CSBMS
Concepts and Theories

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

529-0143-01L Aspects of Modern Inorganic Chemistry: Concepts, Building Blocks, and Polymers

Abstract
General bonding concepts
AIM and ELF as descriptors of electronic structures
GCMT model, carbenes and carbene analogues, homo and heteronuclear unsaturated bonds
Electron precise cluster, electron deficient cluster, and special cluster
General concepts and definitions of inorganic polymers, polysilanes, polysiloxanes, polyphosphazenes

Objective
The course starts with an introduction into general concepts allowing to understand why main group element and transition metal compounds from the higher periods show different properties when compared to their lighter congeners. The Atom in Molecule (AIM) Theory and Electron Localization Function (ELF) will be introduced as means to interpret the electron density distribution in molecules. Carbenes and carbene analogues will be discussed as building blocks for compounds with unsaturated bonds which in turn may serve as precursors to inorganic polymers.
Electron counting rules allow to distinguish different type of clusters which can be divided into electron precise cluster, various electron deficient cluster (for example Wade-Mingos-Cluster), and special cluster.
An introduction into general concepts for syntheses and analyses of inorganic polymers will be given. Specifically, polysilanes, polyphosphazenes and polysiloxanes will be discussed and possible applications of these polymers will be highlighted.

Recent literature will be provided and discussed jointly by the participants of the course (flipped classroom).

The main goal of the lecture is to provide a general understanding of the current literature in the field of modern inorganic chemistry with respect to building blocks used for the synthesis of cluster, polymers, and materials.

Lecture notes
A handout of the presented material will be distributed to the participants of the course. Articles from recent literature will be provided and discussed in the course.

Literature
Original literature is indicated in the course material.

Prerequisites / notice
Basis for the understanding of this lecture are the courses Allgemeine Chemie 1 & 2, and Anorganische Chemie 1: Übergangsmetallchemie.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Taught</th>
<th>assesseds</th>
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</thead>
<tbody>
<tr>
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<td>assessed</td>
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<tr>
<td>Techniques and Technologies</td>
<td></td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
<td></td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
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529-0433-01L Advanced Physical Chemistry: Statistical Thermodynamics

Abstract
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Objective
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Content

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

Prerequisites / notice
Chemical Thermodynamics, Reaction Kinetics, Molecular Quantum Mechanics and Spectroscopy; Mathematical Foundations (Analysis, Combinatorial Relations, Integral and Differential Calculus)

Taught competencies

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529-0455-00L Laser for Micro- and Nanostructuring

Abstract
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as microlithography and laser welding.
Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Objective
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano structuring. Several applications which are still in the research state, e.g. non-optical lithographies, will be discussed together with industrial applications, such as microlithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.
### Content

Introduction to lasers. Overview of micro- and nanotechnology. Microolithography, photoreists: classical types and new developments, laser cutting and welding, laser cleaning, laser ablation, polymer ablation: designed polymers, lasers and surfaces, laser spectroscopy, laser chemical vapor deposition, pulsed laser deposition (PLD), special materials by PLD, alternative structuring methods.

### Subject-specific Competencies

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### Taught competencies

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### Lecture notes

- The script (a copy of the slides) will be handed out during the first lecture.
- Additional handout of slides will be provided during the lectures.

### Literature

- FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.

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### 529-0615-01L Biochemical and Polymer Reaction Engineering

**Abstract**


**Objective**

The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

**Content**

We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes. Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

**Lecture notes**

Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html

**Literature**


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### 529-0837-01L Biomicrofluidic Engineering

**Number of participants limited to 25.**

**Abstract**

Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

**Objective**

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.
Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of heat transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small Volume Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
    Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

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

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

551-0357-00L Cellular Matters: From Milestones to Open Questions

The number of participants is limited to 22 and will only take place with a minimum of 11 participants.

Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using in the subject: 551-0357-00. In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

Abstract
In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Objective
In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.
Content
In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverers on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Lecture notes
The presentations will be made available after the lectures.

Literature
The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

<table>
<thead>
<tr>
<th>Course Code</th>
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<td>752-2000-00L</td>
<td>Food Materials Science</td>
<td>W</td>
<td>4</td>
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<td>R. Mezzenga, G. Nystöm</td>
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<td>752-2314-00L</td>
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<td>W</td>
<td>3</td>
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<td>W</td>
<td>3</td>
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Objective

752-2000-00L
Principles of soft condensed matter applied to food polymers, surfactants and colloids

752-2314-00L
Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

752-3021-00L
S-PRO2 scheme and quantitative understanding of process-structure functions. Process characterisation by dimension analysis.

752-3103-00L
Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

Abstract

752-2000-00L
In Physics of Food Colloids the principles of colloid science will applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloid laws are linked to food science and the manufacturing and processing of food.

752-2314-00L
The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloid laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

752-3021-00L
S-PRO2 scheme, reverse engineering approach, dimension analysis, Metzner-Otto and Rieger Novack design schemes of stirred reactors for non-Newtonian fluid processing, mixing/mixing statistics, mixing characteristics, power charac-teristics, dispersing characteristics, dispersing processes in rotor/ stator and membrane devices, spray processing, extrusion processing, diverse case studies for design and scaling of processes for food structure processing

752-3103-00L
S-Pro2 scheme and quantitative understanding of process-structure functions. Process characterisation by dimension analysis.

Content

752-2000-00L
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

752-2314-00L
Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

752-3021-00L
Notes will be handed out during the lectures.

752-3103-00L
Notes will be handed out during the lectures.

Lecture notes

752-2000-00L
The presentations will be made available after the lectures.

752-2314-00L
Notes will be handed out during the lectures.

752-3021-00L
Provided in the lecture notes.

752-3103-00L
Provided in the lecture notes.

Strength & Durability of Materials (MaP Doctoral School)

Number | Title | Type | ECTS | Hours | Lecturers |
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<td>101-0120-00L</td>
<td>Structural Glass Design and Facade Engineering</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>V.-A. Silvestru</td>
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Objective

101-0120-00L
The course gives an introduction to structural glass design and related facade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.

The course provides an introduction to structural glass design and related facade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.

After successful completion of the course, students will be able to:
- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and chose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Select and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and chose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.

More information on the course can be found in the course syllabus and through the lecturer's office.
This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students with the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent façades.

Design exercises:
The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Design project:
The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

Lecture notes
The lectures are based on lecture slides and handouts.

Literature
Recommended and supplementary literature:

Prerequisites / notice
Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

101-0121-00L Fatigue and Fracture in Materials and Structures  W  4 credits  3G  A. Taras
Does not take place this semester.

Abstract
The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

Objective
In this course, the students will learn:
- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

Content
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner’s damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Linear elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris’ law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and “Laboratory Competition”. The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories). “Laboratory Competition” at Empa: the students with the closest predictions will win the “Empa Laboratory Competition” and will be awarded a prize.
The goal is for students to familiarize themselves with the handling of assessment and rehabilitation of existing structures from the perspective of a consulting engineer, following a systematic approach as described in current codes and to further learn how to use new non-destructive evaluation technologies.

This course is organized in two main pillars. The first pillar describes the technologies that are available for non-destructive evaluation of existing structures and delves into description of the principle of operation of such methods (e.g. wave propagation, acoustic emission analysis, tomography). The second pillar, overviews the current implementation of condition assessment processes in codes and standards. Complementary to the topic of structural evaluation, the topic of interventions, rehabilitation and retrofitting of existing structures for different construction materials is next addressed.

**Literature**


**Prerequisites / notice**

Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

**101-0127-00L Advanced Structural Concrete**

**Abstract**

Within this course, the students are able to:
- deepen their understanding of structural concrete models and apply them to general design problems, including the assessment of existing structures.
- enhance their knowledge about the load-deformation response of reinforced and prestressed concrete structures.
- identify and assess the limits of applicability of limit analysis methods.
- recognise the assumptions of models suitable for computer-aided structural design and use in a critical way structural concrete design software.
- evaluate the long-term behaviour and the behaviour under fire conditions of concrete structures.
- assess the behaviour of fibre reinforced concrete structures.

**Content**

Fundamentals (structural analysis, theorems of limit analysis, applicability of limit analysis methods); shear walls and girders (stress fields and truss models, deformation capacity, membrane elements with yield conditions and load-deformation behaviour, computer-aided structural design); slabs (equilibrium solutions, yield conditions, shear and punching shear, fibre reinforced concrete (mechanical behaviour, applications); long term effects; fire behaviour.

**Lecture notes**

Lecture notes see: http://www.concrete.ethz.ch

**Literature**


**Taught competencies**

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<td>Media and Digital Technologies</td>
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**Social Competencies**

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**101-0129-00L Non Destructive Evaluation & Rehabilitation of Existing Structures**

**Abstract**

Introduction to non destructive evaluation tools and quantitative structural analyses and verifications for condition assessment of existing structures and subsequent decisions on their rehabilitation.

**Objective**

The goal is for students to familiarize themselves with the handling of assessment and rehabilitation of existing structures from the perspective of a consulting engineer, following a systematic approach as described in current codes and to further learn how to use new non-destructive evaluation technologies.

**Content**

This course is organized in two main pillars. The first pillar describes the technologies that are available for non-destructive evaluation of structures and delves into description of the principle of operation of such methods (e.g. wave propagation, acoustic emission analysis, tomography). The second pillar, overviews the current implementation of condition assessment processes in codes and standards. Complementary to the topic of structural evaluation, the topic of interventions, rehabilitation and retrofitting of existing structures for different construction materials is next addressed.

**Lecture notes**

Lecture notes

**Literature**

Swiss Standards SIA 269, 269/1 to 269/7
SIA-Document D 0239 « Existing Structures – Introduction » (in German/French)
SIA-Document D 0239 « Existing Structures – Consolidation and Practice » (in German/French)
A. Costa, A. Arêde, H. Varum, Strengthening and Retrofitting of Existing Structures, Springer, 339p, 2018
Taught competencies

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Communication

Adaptability and Flexibility

K. Tatsis

assessed

Expand the theoretical background and practical knowledge in the design of steel and composite structures. Special composite
Steel Structures III: Advanced Steel and Composite
A. Taras

assessed

This class overview advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to
In Steel Structures III, students will deepen and expand their theoretical background and practical knowledge of the design and
construction of steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. Students will learn how to solve complex structural engineering tasks in larger building projects, e.g. through the use and correct design of large-span slim-floor girders and ultra-slender composite columns, or the use of glazing and cable structures as principal load-carrying components. They learn how steel structures behave under fire conditions and how they can be protected and designed accordingly. Finally, students learn about the fundamental aspects governing the design of specialty steel structures, such as thin-walled cold-formed sections, crane girders, masts and storage tanks.

The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

Structural glazing and lightweight cable-supported structures.

Objective

In Steel Structures III, students will deepen and expand their theoretical background and practical knowledge of the design and

Concrete, Prentice Hall, 1996.

Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems

See the class webpage for more information:

Useful (optional) Reading:

Concrete, Prentice Hall, 1996.

Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

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- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems

See the class webpage for more information:

Useful (optional) Reading:
101-0167-01L Fibre Composite Materials in Structural Engineering

**Objective**

At the end of the course, you shall be able to

1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessary testing and SHM techniques for FRP structures,
3) Continue your education as a PhD student in this field.

**Content**

Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

**Prerequisites / notice**

- 101-0158-01 Method of Finite Elements I (FS)
  - A good knowledge of Python is necessary for attending this course.
- 101-0527-10L Materials and Constructions
  - A good knowledge of Python is necessary for attending this course.

**Literature**

3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019

101-0527-10L Materials and Constructions

**Objective**

The students will acquire knowledge in the following fields:

- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope:
  - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
  - Insulating materials (bio-based vs conventional)
  - Air barrier, vapour barrier and sealants
  - Interior finishing
- Assessment of materials and components behaviour and performance
- Solutions for energy retrofitting of (historical) buildings
- Aspects of sustainability and durability

**Content**

Introduction

Sustainable cement and concrete

Earth construction

Visit

Steel and bamboo

Timber construction

Building physic and conventional insulation

Bio-based insulation

Finishing

Reuse

101-0617-01L Advances in Building Materials

**Objective**

The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

**Prerequisites / notice**

- 101-0158-01 Method of Finite Elements I (FS)
  - A good knowledge of Python is necessary for attending this course.
- 101-0527-10L Materials and Constructions
  - A good knowledge of Python is necessary for attending this course.
This course for civil engineers lays the grounds in the specialization Materials and Mechanics and complements the second introductory course of the specialization on Numerical Mechanics of Materials. The course also addresses master students in Materials Science and other study programs interested in deepening their understanding of application-relevant properties of engineering materials and sustainability related challenges.

The following topics are covered:
1. Material selection
2. Materials and sustainability 1
3. Materials and sustainability 2
4. Recyclability
5. Material science of wood durability
6. Material science of concrete durability
7. Foams in construction and thermal insulation
8. Sealants and adhesives in construction
9. Coatings
10. Flame retardants
11. Future of wood – 1
12. Future of wood – 2
13. Future of concrete – 1
14. Future of concrete – 2

Lecture notes
Handouts will be provided for each lecture.

101-0617-02L Computational Science Investigation for Material Mechanics
W 4 credits 2S D. Kammer, F. Wittel

Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

Objective
Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can often only be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content
1. Introduction to (numeric) forensic engineering
2. The nature of engineering problems (governing equations)
3. Numerical recipes for dealing with non-linear problems
4. Multi-field problems (HTM)
5. On the nature of failure - Physics of damage and fracture
6. Cracks and growth in structures (LEFM and beyond)
7. Introduction to metal plasticity
8. Damage and fracture in heterogeneous materials
9. Mechanics of fatigue
10. Visco-elastic failure
11. Student - Project presentation

Lecture notes
Will be provided during the lecture via moodle.

1.0639-01L Science and Engineering of Glass and Natural Stone in Construction
W 3 credits 2G

Abstract
The course offers an overview of relevant practical issues and present technological challenges for glass and natural stones in constructions. Students gain a good knowledge of the basics of glasses and natural stones, their potential as engineering materials and learn to apply them in the design of civil engineering constructions and to evaluate concepts.
Objective

Glass is increasingly used in constructions to ease the construction process, as functional insulation barrier, even for structural applications of impressive size. While everyone has experienced the innovation potential of glass in the last decade, products from natural stone suffer from an unjustified traditional image that often originates from a lack of understanding of the material and its combination with other materials. Culturally important structures often are made from natural stone and their conservation demands an understanding of their deterioration mechanisms, the concepts of which can be applied to other civil engineering materials. Designers and engineers need the knowledge to reconcile materials and system behavior with the entire processing, handling, integration and life time in mind.

In this module students are provided with a broad fundamental as well as practice-oriented education on glass and natural stone in civil engineering applications. Present and future construction and building concepts demand for such materials with optimized properties. Based on the fundamentals from the Bachelor course in materials by the end of this module, you should be able to:

- recognize and choose specific applications from the broad overview you were provided with,
- relate processing technologies to typical products and building applications and recognize (and explain typical damage related to wrong material choice or application,
- explain the nature of glassy and crystalline materials and interpret their physical behavior against this background,
- explain the major deterioration mechanisms in natural stone and how this relates to durability,
- analyze material combinations and appraise their application in future products as well as integration in existing constructions,
- summarize with appropriate guidance publications on a related topic in an oral presentation and short report.

Content

Lecture 1: An introduction to science and engineering of glass and natural stone in construction (FW/TW)

Lecture 2: Glass chemistry including historical development of glass composition, use of raw materials, melts, chemical stability and corrosion. (FW)

Lecture 3: Geology and mineralogy of stones used in construction. Formation processes, chemistry, crystal structure. (TW)

Lecture 4: Microscopic models for glassy materials. Physics of vitrification. From microscopic physical models to thermodynamics, rheology and mechanics of glassy materials. (FW)

Lecture 5: Stone properties and behavior: microstructure, density, porosity, mechanical properties (TW)

Lecture 6: Glass physics: Optical properties (transmission, reflection, emission, refraction, polarization and birefringence, testing methods); Mechanical properties (density, thermal, mechanical, electric properties, glass testing) (FW)

Lecture 7: Stone properties and durability: transport, moisture and thermal cycling (TW)

Lecture 8: Forming and processing of glass: (plate and molded glass, drawing, slumping, profiling etc.; Processing: Cutting, mechanical processing, tempering, gluing, bending, laminating of glass Surface treatments: coating, sputtering, enameling, printing, etching, chemical pre-stressing.) (FW)

Lecture 9: Durability: Salt crystallization, freezing, biodeterioration (TW)

Lecture 10: Glass products for civil engineering applications: (Molded glasses, fiber glass, foam glass, plate glass); construction glass (insulation glass, structural glass, protective glass, intelligent glass, codes); (FW)

Lecture 11: Conservation: Consolidation, cleaning, and other treatments (TW).

Lecture 12: Glass in constructions. (modelling, application and regulation, typical damage in glass) (FW)

Lecture 13: Student presentations; exam questions (FW/TW)

Lab1: Durability of natural stone (FW/TW)

Lab2: Fracture of glass (FW/TW)

Will be handed out in the lectures

Literature

Werkstoffe II script (download via the IFB homepage). Rest will be handed out in the lectures

Laborkurse I/II of the bachelor studies or equivalent introductory materials lecture.

Prerequisites / notice

Werkstoffe I/II of the bachelor studies or equivalent introductory materials lecture.

Taught competencies

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

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

Social Competencies
Communication assessed
Self-presentation and Social Influence assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Self-direction and Self-management assessed

Abstract

We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.

Durability and Maintenance of Reinforced Concrete
W 4 credits 2V U. Angst, Z. Zhang
After this course you will have profound understanding about:

- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:

- current engineering approaches for durability design (according to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- preventive measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies

Socio-economic challenges related to ageing infrastructures


Degradation mechanisms for concrete: sulphate attack, ASR, frost attack.

Inspection and condition assessment: Chloride analyses, carbonation depth, etc. Non-destructive tests, particularly potential mapping to detect corrosion. New developments (for example, monitoring with sensors).


Stainless steel as reinforcing steel for concrete: Different types of stainless steels. Coupling with black reinforcing steel. Examples of application. Life-cycle-costs.


Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

Excursion:

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

The course is based on the book


Slides of the lectures will be distributed in advance

Special handouts and reprints for particular topics will be distributed


Slides of the lectures will be distributed in advance

Special handouts and reprints for particular topics will be distributed

The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:

We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Concrete Technology

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Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

101-0677-00L

Concrete Technology

W 2 credits 2G

F. Constandopoulos, M. Bäuml, G. Martinola, T. Wangler

Abstract

Opportunities and limitations of concrete technology. Commodities and leading edge specialties.

Objective

Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.
Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as
  - self compacting concrete
  - fiber reinforced concrete
  - fast setting concrete
  - fair faced concrete
  - recycled concrete
- new research in digital fabrication with concrete

Lecture notes
Slides provided for download.

151-0353-00L  Mechanics of Composite Materials  W  4 credits  2V+1U  P. Ermanni, G. Pappas

Abstract  Focus is on laminated fibre reinforced polymer composites. The courses treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

Objective  To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures made from fibre reinforced polymer composites, including elastic behaviour, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Content  The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Variable stiffness structures

Lecture notes  Script, handouts, exercises and additional material are available in PDF-format on the CMASLab webpage resp on moodle.

https://moodle-app2.let.ethz.ch/course/view.php?id=2610

Literature  The lecture material is covered by the script and further literature is referenced in there.

151-0525-00L  Dynamic Behavior of Materials  W  4 credits  2V+2U  D. Mohr, C. Roth, T. Tancogne-Dejean

The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

The course is addressing following topics:
- Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments

Lecture notes  yes
Lectures and computer labs concerned with the modeling of the deformation response and failure of engineering materials (metals, polymers and composites) subject to extreme loadings during manufacturing, crash, impact and blast events.

Students will learn to apply, understand and develop computational models of a large spectrum of engineering materials to predict their behavior under extreme conditions. The course will cover a wide range of topics, from materials science to computational mechanics, with a focus on adaptive materials and their applications.

Various books will be recommended pertaining to the topics covered. The study of adaptive materials covers topics that range from chemistry to theoretical mechanics. The aim of this course is to convey knowledge about adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

### Taught competencies

#### Subject-specific Competencies
- Concepts and Theories
- Technics and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork

#### Personal Competencies
- Creative Thinking
- Critical Thinking

### Prerequisites / notice

Course in continuum mechanics (mandatory), finite element method (recommended)

### Literature

Various books will be recommended pertaining to the topics covered.

### Prerequisites / notice

Course in continuum mechanics (mandatory), finite element method (recommended)

### 151-0529-00L

**Computational Mechanics II: Nonlinear FEA**

**W** 4 credits 2V+2U

**L. De Lorenzis**

**Abstract**

The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

**Objective**

To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

**Content**

1. Introduction: various sources of nonlinearities and implications for FEA.

### Prerequisites / notice

Lecture notes will be provided. However, students are encouraged to take their own notes.

### 151-0544-00L

**Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis**

**W** 4 credits 3G

**E. Hosseini**

**Abstract**

An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

**Objective**

The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAOUS) for simulation of the MAM process.

**Content**

- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (steels, Ti6Al4V, Inconel, Al alloys),
- Design for additive manufacturing
- Artificial intelligence for AM

Exercise sessions use COMSOL, ANSYS, ABAOUS packages for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. COMSOL, ANSYS and ABAOUS agreed to support the course by providing licenses for the course attendees and therefore the students can install the packages on their own systems.

### Lecture notes

Handouts of the presented slides.

### Literature

No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, recommendations for additional literature/publications will be given (for each individual topic).

### Prerequisites / notice

A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.
Content
This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions. Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion


Thermo-mechanical coupling: Shape memory alloys / polymers

Electromechanical coupling: DEA, EBL, electrorheological fluids

Shape control / morphing: Use, requirements, challenges

Morphing applications of variable stiffness structures: Lab work

Electromechanical coupling (2): Piezoelectric, electrostrictive effect

Vibration Reduction: Measurement, passive, semi-active (active) damping methods

Vibration reduction applications of piezoelectric materials: Lab work

Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials

Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Self-direction and Self-management

Lecture notes (manuscript and handouts) will be provided

Subject-specific Competencies
Not assessed

Method-specific Competencies
Not assessed

Social Competencies
Not assessed

Personal Competencies
Not assessed

Abstract
Moisture Transport in Porous Media

Objective
- Basic knowledge of moisture transport and related degradation processes in porous materials
- Knowledge of experimental determination of moisture transport properties
- Knowledge of pore network model and application to two-phase invasion percolation simulation
- Application of knowledge to moisture transport in cracked materials and flow in deformable porous media

Content
1. Introduction
Moisture damage: problem statement, durability
Applications: building materials, soil science, geoscience

2. Moisture transport: theory and application
Description of moisture transport
Determination of moisture transport properties
Liquid transport in cracked materials, flow and transport in deformable porous media

3. Pore network model: theory and application
Single- and two-phase pore network model: quasi-static and dynamic
Exercise on quasi-static two-phase pore network model: invasion pattern, capillary pressure curve
Application of pore network model in two-phase transport

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Literature
All material is provided online via Moodle.

Programme code 151-8015-00L
Lecturer J. Carmeliet, L. Fei, D. A. Strebel

Course Title
Moisture Transport in Porous Media

Objective
- Basic knowledge of moisture transport and related degradation processes in porous materials
- Knowledge of experimental determination of moisture transport properties
- Knowledge of pore network model and application to two-phase invasion percolation simulation
- Application of knowledge to moisture transport in cracked materials and flow in deformable porous media

Content
1. Introduction
Moisture damage: problem statement, durability
Applications: building materials, soil science, geoscience

2. Moisture transport: theory and application
Description of moisture transport
Determination of moisture transport properties
Liquid transport in cracked materials, flow and transport in deformable porous media

3. Pore network model: theory and application
Single- and two-phase pore network model: quasi-static and dynamic
Exercise on quasi-static two-phase pore network model: invasion pattern, capillary pressure curve
Application of pore network model in two-phase transport

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Literature
All material is provided online via Moodle.
Objective
In this course you will get an inside to lightweight material with high strength, materials that are resistive against abrasion, ceramics with damage tolerance behavior, composites with bioactive, bioresorbable, piezoresistive and -electric properties. Enables materials scientists to design composite/hybrid materials for different applications. The course will comprise a balance of lectures, exercises and laboratory classes.

Content
Introduction and basic concepts on biomedical composites and smart composites/hybrids with sensing and actuation properties; production and properties of composites reinforced with particles, whiskers, short or long fibers; selection criteria, case studies and applications, future perspectives.

1. Structural composites (polymer-, metal- and ceramic matrix composites)
   1.1. Introduction and historical background
   1.2. Components: Matrix and reinforcement materials
   1.3. Types of composites and mechanisms of reinforcement
   1.4. Production processes
   1.5. Physical and chemical properties
   1.6. Applications

2. Biomedical Composites
   2.1. Introduction and historical background
   2.2. Components: metals&alloys, natural/synthetic polymers, bioceramics
   2.3. Types of biocomposites
   2.4. Production processes
   2.5. Properties
   2.6. Applications

3. Functional Composites (Sensors and Actuators)
   3.1. Introduction and historical background
   3.2. Components: Matrix and functional filler material
   3.3. Types of composites
   3.4. Production processes
   3.5. Properties
   3.6. Applications

Lecture notes
We will work with handouts

Literature

Biomedical composites, J. Paulo Davin (Ed.), De Gruyter (2014)


Bioresorbable polymers for biomedical applications – from fundamentals to translational medicine, G. Perale, J. Hilborn (Eds), Woodhead Publishing (2017)


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

Method-specific Competencies
- Analytical Competencies not assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management not assessed

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

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

376-0021-00L Materials and Mechanics in Medicine W 4 credits 3G M. Zenobi-Wong, J. G. Snedeker
Objective
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
course website on Moodle

Literature

376-0022-00L Sustainable & Bioinspired Materials (MaP Doctoral School)
Objective
Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction.
I. Burgert

2G

D. Ahmed

assessed

3G

G. von Arx

- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Special focus on regenerative materials: earth, bio-based and reuse

Analytical Competencies

151-0509-00L

Acoustics in Fluid Media: From Robotics to Additive Manufacturing

No script. Lecture slides and literature will be made available on Moodle.

Prerequisites / notice

Methods to be learned in this course: basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g., Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Content

This course has the aim of deepening students’ knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the
- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multisetup processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

Lecture notes

No script. Lecture slides and literature will be made available on Moodle.

Literature

Literature will be made available on Moodle.

Method-specific Competencies

Personal Competencies

102-0317-00L

Advanced Environmental Assessments

Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0317-00 Advanced Environmental Assessments (3KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

Objective

This course deepens students' knowledge of the environmental assessment methodologies and their various applications.

Content

This course has the aim of deepening students' knowledge of the environmental assessment methodologies and their various applications.

- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multisetup processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

Lecture notes

No script. Lecture slides and literature will be made available on Moodle.

Literature

Literature will be made available on Moodle.

Subject-specific Competencies

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g., Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Abstract

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices
Lecture notes


Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

Taught competencies

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

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed

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

Personal Competencies
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-direction and Self-management: assessed

151-0524-00L Continuum Mechanics I W 4 credits 2V+1U A. E. Ehret

Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.

Content
- Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory,
- Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments

Lecture notes
yes

227-0393-10L Bioelectronics and Biosensors W 6 credits 2V+2U J. Vörös, M. F. Yanik

Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field

Content
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Lecture notes
Script with more than 600 pages with many illustrations will be distributed free of charge.

Literature
3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

Prerequisites / notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

327-1221-00L Biological and Bio-Inspired Materials W 4 credits 3G A. R. Studart, I. Burgert, R. Nicolosi Libanori, G. Panzarasa

Abstract
The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials.

Objective
The course first offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials. Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.

Content
This course is structured in 3 blocks:

Block (I): Fundamentals of engineering in biological materials
- Biological engineering principles
- Basic building blocks found in biological materials

Block (II): Replicating biological design principles in synthetic materials
- Biological and bio-inspired materials: polymer-reinforced and ceramic-toughened composites
- Lightweight biological and bio-inspired materials
- Functional biological and bio-inspired materials: surfaces, self-healing and adaptive materials

Block (III): Bio-inspired design and systems
- Mechanical actuation - plant systems
- Bio-inspiration in the built environment

Lecture notes
Copies of the slides will be made available for download before each lecture.

Literature
The course is mainly based on the books listed below. Additional references will be provided during the lectures.

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Prior experience with the programming language Python is beneficial but not mandatory. ETH offers courses for practical programming with Python.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions Courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (QA).

Following the QA, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.
Objective

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

Content

Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks the technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photons, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

Prerequisites / notice

A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

376-1622-00L Practical Methods in Tissue Engineering

Number of participants limited to 12.

Abstract

The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

Objective

Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Content

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Literature


Handouts and references therein.

376-1714-00L Biocompatible Materials

Abstract

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

Handouts are deposited online (moodle).

Literature:


(available online via ETH library)

376-1974-00L Colloquium in Biomechanics

Abstract

Current topics in biomechanics presented by speakers from academia and industry.

Objective

Getting insight into actual areas and problems of biomechanics.

529-0615-01L Polymerization and Polymer Reaction Engineering

Abstract


Objective

The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.
Content

We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes, kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

Lecture notes

Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html

Additional handout of slides will be provided during the lectures.

Literature

H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Group</th>
<th>Lecturer</th>
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<tr>
<td>529-0837-01L</td>
<td>Biomicrofluidic Engineering</td>
<td>6</td>
<td>W</td>
<td>A. de Mello</td>
</tr>
</tbody>
</table>

**Abstract**

Microfluidics describes the behavior, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

**Objective**

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

**Content**

Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   - Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   - Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   - Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   - Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Pélet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   - Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   - Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   - Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   - Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small Volume Molecular Detection
   - Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    - Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
    - Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

   Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

   There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

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

   **Method-specific Competencies**
   - Analytical Competencies: assessed
   - Decision-making: assessed
   - Media and Digital Technologies: assessed
   - Problem-solving: assessed
   - Project Management: assessed

   **Social Competencies**
   - Communication: assessed
   - Cooperation and Teamwork: assessed

   **Personal Competencies**
   - Adaptability and Flexibility: assessed
   - Creative Thinking: assessed
   - Critical Thinking: assessed

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 782 of 2345
Abstract

Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective

Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content

The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:

- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI Imaging
- Scanning tunnelling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations

Lecturers

E. J. Windhab

Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press

Lecturers

E-Learning and Workshop (MaP Doctoral School)


Prerequisites / notice

The module is composed of 3 SWS (3 hours/week); 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

Transferable Skills

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>327-2226-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students (MaP Doctoral School)</td>
<td>W</td>
<td>1 credit</td>
<td>2U</td>
<td>L. Schefer, S. Stepanow, M. Trassin</td>
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<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days)</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0101-DRL</td>
<td>Transferable Skills Course II (1-3 days)</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Note: Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
### Transferable Skills Course III (1-3 days)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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### Transferable Skills Course I (1-3 days, with Poster or Talk)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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### Transferable Skills Course II (1-3 days, with Poster or Talk)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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### Transferable Skills Course III (1-3 days, with Poster or Talk)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

---

### Transferable Skills Course I (min 4 days)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

---

### Transferable Skills Course II (min 4 days)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

---

### Transferable Skills Course III (min 4 days)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

---

### Transferable Skills Course I (min 4 days, with Poster or Talk)

Only for doctoral students.

**Abstract**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.
Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL Transferable Skills Course II (min 4 days, with Poster or Talk) Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL Transferable Skills Course III (min 4 days, with Poster or Talk) Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year) Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Active participation in the presidium or executive board of a university group for at least 1 year.

Objective Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<td>Summer School I (1-3 days) Only for doctoral students.</td>
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<td>2K</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a maximum duration of 3 days.

Objective Participation in summer or winter schools with a maximum duration of 3 days.

900-0151-DRL | Summer School II (1-3 days) Only for doctoral students. | W    | 1    | 2K    | Lecturers |

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a maximum duration of 3 days.

Objective Participation in summer or winter schools with a maximum duration of 3 days.

900-0152-DRL | Summer School III (1-3 days) Only for doctoral students. | W    | 1    | 2K    | Lecturers |

Please select your doctoral thesis supervisor as a lecturer
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<th>Name</th>
<th>Duration</th>
<th>Credits</th>
<th>Lecturers</th>
<th>Abstract</th>
<th>Objective</th>
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<td>2</td>
<td>4K</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<td>Participation in summer or winter schools with a minimum duration of 4 days. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<td>900-0161-DRL</td>
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<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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</table>
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0162-DRL
External Conference I (incl. Poster or Talk)
Only for doctoral students.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0163-DRL
External Conference II (incl. Poster or Talk)
Only for doctoral students.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0164-DRL
External Conference III (incl. Poster or Talk)
Only for doctoral students.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Doctorate Materials Science - Key for Type

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

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

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### A PDE Approach to Mean-Field Disordered Systems

**Number**: 401-5003-72L  
**Type**: Lecture  
**ECTS**: 2 credits  
**Hours**: 2V  
**Lecturers**: J.-C. Mourrat

**Abstract**: Nachdiplom lecture

**Content**: The goal of statistical mechanics is to describe the large-scale behavior of collections of simple elements, often called spins, that interact through locally simple rules and are influenced by some amount of noise. We will discuss three classes of such models, of increasing difficulty, and will rely on a common PDE approach to study each of them.

The first model we will study is the very simple Curie-Weiss model, in which every spin interacts with every other spin and has a preference for being aligned with the others. This model can be solved in a variety of ways, but will be used to develop our toolkit based on the study of certain Hamilton-Jacobi equations that naturally arise.

We will then turn to a more challenging class of models coming from statistical inference. We will focus on a setup in which we observe a noisy version of a large rank-one matrix. We will compute the information-theoretic limit to the recovery of this matrix based on the PDE techniques introduced earlier.

We will finally discuss spin-glass models, in which the local interactions between the spins are disordered. One of the core motivations for the development of the techniques presented here is to uncover the behavior of models in which spins can be of different types, such as for instance when the spins are organized over two layers, and only have direct interactions across layers. While the understanding of this class of models is still very limited, I will present some progress towards this goal.

**Prerequisites / notice**: The prerequisites for these lectures are basic measure theory and probability theory. No prior knowledge of PDE theory will be assumed.
**401-3533-71L**  
**Generalized Nonpositive Curvature**  
CAT(0) spaces, Busemann convex spaces, spaces with convex geodesic bicomings, injective metric spaces and injective hulls, Gromov hyperbolicity, Helly graphs and Helly groups.  

**401-3509-00L**  
**Combinatorics II**  
Does not take place this semester.  

**401-3505-64L**  
**Algebraic Methods in Combinatorics**  
Does not take place this semester.  

**401-4657-00L**  
**Numerical Solution of Stochastic Ordinary Differential Equations**  
Alternative course titles: "Numerical Analysis of Stochastic Ordinary Differential Equations" / "Computational Methods for Quantitative Finance: Monte Carlo and Sampling Methods"  

### Prerequisites / notice

You should know the basics of point-set topology.

Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course "topology").

Some knowledge of differential geometry and differential topology is useful but not strictly necessary.

Some (elementary) group theory and algebra will also be needed.

### Literature

The aim of this course is to review new and fundamental mathematical tools, computational approaches, and inversion and optimal design methods used to address challenging problems in nanophotonics. The emphasis will be on analyzing plasmon resonant nanoparticles, super-focusing & super-resolution of electromagnetic waves, photonic crystals, electromagnetic cloaking, metamaterials, and metasurfaces.

The field of photonics encompasses the fundamental science of light propagation and interactions in complex structures, and its technological applications.

The recent advances in nanoscience present great challenges for the applied and computational mathematics community. In nanophotonics, the aim is to control, manipulate, reshape, guide, and focus electromagnetic waves at nanometer length scales, beyond the resolution limit. In particular, one wants to break the resolution limit by reducing the focal spot and confine light to length scales that are significantly smaller than half the wavelength.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare. Light-based technologies can be used effectively for the very early detection of diseases, with non-invasive imaging techniques or point-of-care applications. They are also instrumental in the analysis of processes at the molecular level, giving a greater understanding of the origin of diseases, and hence allowing prevention along with new treatments. Photonic technologies also play a major role in addressing the needs of our aging society: from pace-makers to synthetic bones, and from endoscopes to the micro-cameras used in in-vivo processes. Furthermore, photonics are also used in advanced lighting technology, and in improving energy efficiency and quality. By using photonic media to control waves across a wide band of wavelengths, we have an unprecedented ability to fabricate new materials with specific microstructures.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonic crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-mathematics in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena. An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecture</th>
<th>Instructor</th>
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<tr>
<td>401-4785-00L</td>
<td>Mathematical and Computational Methods in Photonics</td>
<td>8</td>
<td>H. Ammari</td>
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<tr>
<td>401-4944-20L</td>
<td>Mathematics of Data Science</td>
<td>8</td>
<td>A. Bandeira</td>
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<tr>
<td>401-3621-00L</td>
<td>Fundamentals of Mathematical Statistics</td>
<td>10</td>
<td>S. van de Geer</td>
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<tr>
<td>401-3622-00L</td>
<td>Statistical Modelling</td>
<td>8</td>
<td>P. L. Bühlmann</td>
<td></td>
</tr>
</tbody>
</table>

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei
Content

Prerequisites / notice
This is the course unit with former course title "Regression"

Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

### 401-4623-00L Time Series Analysis

| Objective |
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

Literature
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice
Basic knowledge in probability and statistics

### 401-3627-00L High-Dimensional Statistics

Abstract
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Objective
Knowledge of methods and basic theory for high-dimensional statistical inference

Content
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and 1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

Literature
Peter Bühlmann and Sara van de Geer (2011), Statistics for High-Dimensional Data: Methods, Theory and Applications. Springer Verlag.

Prerequisites / notice
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

### 401-3612-00L Stochastic Simulation

Abstract
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

Objective
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Content
Examples of simulations in different fields (computer science, statistics, statistical mechanics, operations research, financial mathematics).
- Generation of uniform random variables.
- Generation of random variables with arbitrary distributions (quantile transform, accept-reject, importance sampling), simulation of Gaussian processes and diffusions. The precision of simulations, methods for variance reduction.
- Introduction to Markov chains and Markov chain Monte Carlo (Metropolis-Hastings, Gibbs sampler, Hamiltonian Monte Carlo, reversible jump MCMC).

Lecture notes
A script will be available in English.

Literature

Prerequisites / notice
Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

### 401-3628-14L Bayesian Statistics

Abstract
Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayes cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

Objective
Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.

Content
Topics that we will discuss are:

- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)

Lecture notes
A script will be available in English.

Literature

Additional references will be given in the course.
Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.

This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include:
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- additional topics

Content
This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include:
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- and probably others

Lecture notes
The course is based on different parts from different books as well as on original research literature.

Lecture notes will not be available.

Prerequisites / notice
Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

Courses:

1. **Mathematical Finance**
   - **401-4889-00L**
   - **W 11 credits 4V+2U**
   - **D. Possamaï**
   - **Abstract**
     Advanced course on mathematical finance:
     - semimartingales and general stochastic integration
     - absence of arbitrage and martingale measures
     - fundamental theorem of asset pricing
     - option pricing and hedging
     - hedging duality
     - optimal investment problems
     - additional topics
   - **Objective**
     Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes).
   - **Content**
     Topics include:
     - semimartingales and general stochastic integration
     - absence of arbitrage and martingale measures
     - fundamental theorem of asset pricing
     - option pricing and hedging
     - hedging duality
     - optimal investment problems
     - and probably others
   - **Lecture notes**
     The course is based on different parts from different books as well as on original research literature.

2. **Statistical Physics**
   - **402-0861-00L**
   - **W 10 credits 4V+2U**
   - **E. Demler**
   - **Abstract**
     This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.
   - **Objective**
     This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.
   - **Content**
     Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.
     Classical statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.
     Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons.
     Identical quantum particles: many body wave functions, second quantization formalism, equation of motion, correlation functions, selected applications, e.g. Bose-Einstein condensate and coherent state, phonons in elastic media and melting.
     One-dimensional interacting systems.
     Phase transitions; mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls’ arguments on long-range order.
   - **Lecture notes**
     Lecture notes available in English.

3. **General Relativity**
   - **402-0830-00L**
   - **W 10 credits 4V+2U**
   - **L. Senatore**
   - **Abstract**
     Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.
   - **Objective**
     Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).
   - **Content**
     Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.
   - **Literature**
     Suggested textbooks:
     - C. Misner, K. Thorne and J. Wheeler: Gravitation
     - S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
     - R. Wald - General Relativity
     - S. Weinberg - Gravitation and Cosmology

4. **Quantum Field Theory I**
   - **402-0843-00L**
   - **W 10 credits 4V+2U**
   - **R. Renner**
   - **Abstract**
     Special Students UZH must book the module PHY551 directly at UZH.
   - **Objective**
     Special Students UZH must book the module PHY551 directly at UZH.
This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity. Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

Lecture notes will be provided as the course progresses.

Abstract

Introduction to String Theory

Does not take place this semester.

Abstract

String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Objective

Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Content

- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- D-branes, T-duality
- supergravity as a low-energy effective theory, strings on curved backgrounds
- two-dimensional field theories (classical/quantum, conformal/non-conformal)

Literature

M.B. Green, J.H. Schwarz, E. Witten, Superstring Theory I, CUP (1987).

Prerequisites / notice

Recommended: Quantum Field Theory I (in parallel).

Randomized Algorithms and Probabilistic Methods

Abstract

Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

Objective

After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content

Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes

Yes.

Literature


Image Analysis and Computer Vision

Abstract


Objective

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
Content

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

227-0417-00L Information Theory I

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

227-0423-00L Neural Network Theory

Abstract

Does not take place this semester.

Objective

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Content

1. Universal approximation with single- and multi-layer networks

2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory

3. Fundamental limits of deep neural network learning

4. Geometry of decision surfaces

5. Separating capacity of nonlinear decision surfaces

6. Vapnik-Chervonenkis (VC) dimension

7. VC dimension of neural networks

8. Generalization error in neural network learning

Lecture notes

Detailed lecture notes are available on the course web page https://www.mins.ee.ethz.ch/teaching/nnt/

Prerequisites / notice

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

151-0563-01L Dynamic Programming and Optimal Control

Abstract


Objective


Content

Prerequisites: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Literature

Problems: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

401-3054-14L Probabilistic Methods in Combinatorics

Abstract

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content

The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

Literature

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

401-4607-68L Topics on the Gaussian Free Field

Abstract

We will discuss various aspects and properties of the Gaussian Free Field.

Content

Topics discussed will include:
- Discrete and continuous Gaussian Free Field
- Local sets.
- Relation to loop-soups.
- Uniform spanning trees.

Seminars

Number

Title

Type

ECTS

Hours

Lecturers

401-4600-72L Student Seminar in Probability

Limited number of participants. Registration to the seminar will only be effective once confirmed by email from the
organisers.

This Student Seminar in Probability will be at an advanced level (dealing with current research topics), and the participants will be at a doctoral level or postdocs. Of course, non-participants are welcome to attend the various talks of the seminar.

Content

The seminar is centered around a topic in probability theory which changes each semester. The number of participants to the seminar is limited. Registration to the seminar will only be effective once confirmed by email from the organizers.

#### Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
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<td>401-5990-00L</td>
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<td>A. Iozi, further speakers</td>
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<td>401-5660-00L</td>
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<td>401-5910-00L</td>
<td>Talks in Financial and Insurance Mathematics</td>
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<td>B. Acciaio, P. Cheridito, D. Possamai, M. Schweizer, J. Teichmann, M. V. Wüthrich</td>
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<td>252-4202-00L</td>
<td>Seminar in Theoretical Computer Science</td>
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<td>E. Welzl, B. Gärtner, M. Hoffmann, J. Lengler, A. Steger, D. Steurer, B. Sudakov</td>
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</table>

Abstract

Presentation of recent publications in theoretical computer science, including results by diploma, masters and doctoral candidates.
## Objective

The goal is to introduce students to current research, and to enable them to read, understand, and present scientific papers.

## Prerequisites / notice

This seminar takes place as part of the joint research seminar of several theory groups. Intended participation is for students with excellent performance only. Formal restriction is: prior successful participation in a master level seminar in theoretical computer science.

### Transferable Skills

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<td>900-0114-DRL</td>
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### Integration into Scientific Community

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**Abstract**
Participation in summer or winter schools with a minimum duration of 4 days.

**Objective**
Participation in summer or winter schools with a minimum duration of 4 days.

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**Doctorate Mathematics - Key for Type**

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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 799 of 2345
### Key for Hours

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**ECTS**  
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Doctorate Physics

Subject Specialisation
Please note that this is an INCOMPLETE list of courses.

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<tr>
<th>Number</th>
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<td>Semiconductor Materials: Fundamentals and Fabrication</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>S. Schön, W. Wegscheider</td>
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Abstract
This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective
Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

Content
1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes
https://moodle-app2.let.ethz.ch/course/view.php?id=

Prerequisites / notice
The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

402-0395-10L Black Holes and Gravitational Waves W 8 credits 4G L. Heisenberg, F. D'Ambrosio, A. Giusti

Abstract
The course will discuss some hot topics in gravitational physics, providing an overview on the necessary formalism and its applications to black hole physics and gravitational waves.

Objective
The course aims at providing a general introduction to the necessary tools needed to approach two very active research topics in gravitational physics: 1) theoretical black hole physics; 2) gravitational waves. Time permitting, more formal concepts like the initial value problem in general relativity and quasi-local notions of horizon will be discussed. The course will include a brief introduction to general relativity and differential geometry.

Contents:
1. Brief introduction to Differential Geometry and General Relativity;
2. Elementary black hole solutions in general relativity and their properties;
3. Conserved charges;
4. Geometry of hypersurfaces and horizons;
5. Singularity theorems;
6. Hawking radiation and the information loss paradox;
7. Generalities on gravitational waves;
8. Phenomenology of black hole mergers

Lecture notes
Lecture notes and/or slides will be made available prior to each lecture.

Literature
N. Straumann, General Relativity, (Springer, 2013)
P. Jetzer, Applications of General Relativity, (Springer, 2022)

402-0442-00L Quantum Optics W 10 credits 3V+2U A. Imamoglu

Abstract
This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

Objective
The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

Content
This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:
- coherence properties of light
- quantum nature of light: statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

Lecture notes
Selected book chapters will be distributed.
Literature

Text-books:

- G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
- R. Loudon, The Quantum Theory of Light
- Atomic Physics, Christopher J. Foot
- Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
- C. Cohen-Tannoudji et al., Atom-Photon-Interactions
- M. Scully and M.S. Zubairy, Quantum Optics
- Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

402-0442-05L Advanced Topics in Quantum Optics

Number of participants limited to 25.

Abstract
The lecture will cover current topics and scientific papers in the wider field of quantum optics in an interactive format. First, the research area will be introduced, then several papers of this field will be presented by the students in the style of a journal club. Selected papers will be contrasted and their strengths and weaknesses discussed by the students in panel discussions. Furthermore, r

Objective
The aim of the lecture is to deepen and broaden the knowledge about current research in the field of quantum optics. In addition, it will also be discussed and critically examined how research results are communicated via publications and lectures and which techniques are used in the process.

Content
We will select topical fields in quantum optics and quantum science and discuss recently published work.

Topics:
- Atoms or ions-based quantum computing
- Quantum simulation
- Opto-mechanics
- Driven and dissipative quantum systems
- Cavity based atom-light interaction
- Topological photonics

The interactive part of the lecture will include presentations of recent papers, panel discussions of recent papers and the writing of a critical assessment of an arXiv paper in the style of a referee report.

402-0457-00L Quantum Technologies for Searches of New Physics

Abstract
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

Objective
The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

Content
The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.

- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces.

402-0484-00L Experimental and Theoretical Aspects of Quantum Gases

Abstract
Quantum Gases are the most precisely controlled many-body systems in physics. This provides a unique interface between theory and experiment, which allows addressing fundamental concepts and long-standing questions. This course lays the foundation for the understanding of current research in this vibrant field.

Objective
The lecture conveys a basic understanding for the current research on quantum gases. Emphasis will be put on the connection between theory and experimental observation. It will enable students to read and understand publications in this field.

Content
Cooling and trapping of neutral atoms

Bose and Fermi gases

Ultracold collisions

The Bose-condensed state

Elementary excitations

Vortices

Superfluidity

Interference and Correlations

Optical lattices

Lecture notes
notes and material accompanying the lecture will be provided

Literature


402-0465-58L Intersubband Optoelectronics

Does not take place this semester.

Abstract
Quantum Gases are the most precisely controlled many-body systems in physics. This provides a unique interface between theory and experiment, which allows addressing fundamental concepts and long-standing questions. This course lays the foundation for the understanding of current research in this vibrant field.

Objective
The lecture conveys a basic understanding for the current research on quantum gases. Emphasis will be put on the connection between theory and experimental observation. It will enable students to read and understand publications in this field.

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Cooling and trapping of neutral atoms

Bose and Fermi gases

Ultracold collisions

The Bose-condensed state

Elementary excitations

Vortices

Superfluidity

Interference and Correlations

Optical lattices

Lecture notes
notes and material accompanying the lecture will be provided

Literature


Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

Objective
After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview over state of the art experimental techniques used to study fast processes.

Content
1. Experimental techniques, an overview
   2. Dynamics of the electron gas
      2.1 First experiments on electron dynamics and lattice heating
      2.2 The finite lifetime of excited states
      2.3 Detection of lifetime effects
      2.4 Dynamical properties of reactions and adsorbents
   3. Dynamics of the lattice
      3.1 Phonons
      3.2 Non-thermal melting
   4. Dynamics of the spin system
      4.1 Laser induced ultrafast demagnetization
      4.2 Ultrafast spin currents generated by lasers
      4.3 Landau-Lifschitz-Dynamics
      4.4 Laser induced switching
   5. Correlated materials will be distributed

Lecture notes
The lecture can also be followed by interested non-physics students as basic concepts will be introduced.

Literature
relevant publications will be cited

Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum mechanics.

402-0464-00L Optical Properties of Semiconductors

W 8 credits 2V+2U G. Scalari

Abstract
This course presents a comprehensive discussion of optical processes in semiconductors.

Objective
The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these material, enabled numerous applications (lasers, LEDs and solar cells) as well as the realization of new practical concepts. Systems that will be covered include quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

Content
Electronic states in III-V materials and quantum structures, optical transitions, excitons and polaritons, novel two dimensional semiconductors, spin-orbit interaction and magneto-optics.

Prerequisites / notice
Prerequisites: Quantum Mechanics I, Introduction to Solid State Physics

402-0526-00L Ultrafast Processes in Solids

W 6 credits 2V+1U Y. M. Acremann

Abstract
Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

Objective
After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview over state of the art experimental techniques used to study fast processes.

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Lecture notes
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Literature
relevant publications will be cited

Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum mechanics.

402-0535-00L Introduction to Magnetism

W 6 credits 3G A. Vindigni

Abstract
Atomic paramagnetism and diamagnetism, itinerant and local-moment interatomic coupling, magnetic order at finite temperature, spin precession, approach to equilibrium through thermal and quantum dynamics, dipolar interaction in solids.

Objective
- Identify the mechanisms from which exchange interaction originates in solids (itinerant and local-moment magnetism)
- Evaluate the consequences of the interplay between competing interactions and thermal energy
- Apply general concepts of statistical physics to determine the origin of bistability in realistic magnets
- Discriminate the dynamic responses of a magnet to different external stimuli

Content
The lecture “Introduction to Magnetism” is a regular course of the Physics MSc program and aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what “being magnetic” means is essential to address this question properly. Theoretical concepts will be applied to few selected nano-sized magnets, which will serve as clean reference systems. At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Preliminary contents for the HS21:
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetic order in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field)
- Spin resonance and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)
- Magnetic order at finite temperatures (Ising and Heisenberg models, low-dimensional magnetism)
- Dipolar interaction in solids (shape anisotropy, dipolar frustration, origin of magnetic domains)
Learning material will be made available through a dedicated RStudioServer and through Moodle.

Prerequisites / notice

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoelectromagnetism.

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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecture Type</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0468-15L</td>
<td>Nanomaterials for Photonics</td>
<td>W 6</td>
<td>2V+1U</td>
<td>R. Grange</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.</td>
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<td><strong>Objective</strong></td>
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<td>The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.</td>
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<td></td>
<td><strong>Content</strong></td>
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</tr>
</tbody>
</table>
|             | 1. Introduction to nanomaterials for photonics  
|             | a. Classification of nanomaterials  
|             | b. Light-matter interaction at the nanoscale  
|             | c. Examples of nanophotonic devices  
|             | 2. Wave physics for nanophotonics  
|             | a. Wavelength, wave equation, wave propagation  
|             | b. Dispersion relation  
|             | c. Interference  
|             | d. Scattering and absorption  
|             | e. Coherent and incoherent light  
|             | 3. Analogies between photons and electrons  
|             | a. Quantum wave description  
|             | b. How to confine photons and electrons  
|             | c. Tunneling effects  
|             | 4. Characterization of Nanomaterials  
|             | a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED  
|             | b. Light scattering techniques: DLS  
|             | c. Near field microscopy: SNOM  
|             | d. Electron microscopy: SEM, TEM  
|             | e. Scanning probe microscopy: STM, AFM  
|             | f. X-ray diffraction: XRD, EDS  
|             | 5. Fabrication of nanomaterials  
|             | a. Top-down approach  
|             | b. Bottom-up approach  
|             | 6. Plasmonics  
|             | a. What is a plasmon, Drude model  
|             | b. Surface plasmon and localized surface plasmon (sphere, rod, shell)  
|             | c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering  
|             | d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication  
|             | e. Applications  
|             | 7. Organic and inorganic nanomaterials  
|             | b. Carbon nanotubes: properties, bandgap description, fabrication  
|             | c. Graphene: motivation, fabrication, devices  
|             | d. Nanomarkers for biophotonics  
|             | 8. Semiconductors  
|             | a. Crystalline structure, wave function  
|             | b. Quantum well: energy levels equation, confinement  
|             | c. Quantum wires, quantum dots  
|             | d. Optical properties related to quantum confinement  
|             | e. Example of effects: absorption, photoluminescence  
|             | f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade  
|             | 9. Photonic crystals  
|             | a. Analogy photonic and electronic crystal, in nature  
|             | b. 1D, 2D, 3D photonic crystal  
|             | c. Theoretical modelling: frequency and time domain technique  
|             | d. Features: band gap, local enhancement, superprism...  
|             | 10. Nanocomposites  
|             | a. Effective medium regime  
|             | b. Metamaterials  
|             | c. Multiple scattering regime  
|             | d. Complex media: structural colour, random lasers, nonlinear disorder  

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>402-0595-00L</td>
<td>Semiconductor Nanostructures</td>
<td>W 6</td>
<td>2V+1U</td>
<td>T. M. Ihn</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.</td>
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</tbody>
</table>

Lecture notes:

Slides and book chapter will be available for downloading

Literature:

References will be given during the lecture

Prerequisites / notice:

Basics of solid-state physics (i.e. energy bands) can help
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate

1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one

1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
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11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

You will be able to present and discuss:

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
- Communication
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrons, muons and exotic atoms.

You will be able to present and discuss:

- the principle of the experiments
- the underlying technique and methods
- the context and the impact of these experiments on particle physics

Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics," making use of high precision and high intensities.

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrons and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:

- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spin manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling....
Neutrino Physics

Abstract
Theoretical basis and selected experiments to determine the properties of neutrinos and their interactions (mass, spin, helicity, chirality, oscillations, interactions with leptons and quarks).

Objective
Introduction to the physics of neutrinos with special consideration of phenomena connected with neutrino masses.

Lecture notes
Script

Literature


D.O. Caldwell, Current Aspects of Neutrino Physics, Springer.


Advanced Topics of General Relativity and Gravitational Waves (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: PHY529

Abstract
The aim of this lecture is to discuss some advanced topics in general relativity, which are useful to understand the present research activities in the field. A list of possible topics is given below. A basic knowledge of general relativity is required (ideally having followed the lecture on General Relativity). The course is particularly suited for master and PhD students.

Objective
To be able to read and understand the original literature and the presently published papers in the field of the discussed advanced topics. This might be also useful in view of doing afterwards a master thesis in the field of general relativity.

Content
Possible content:
- General relativistic stellar structure equations (Neutron stars)
- Tetrad formalism
- Spinors in GR
- Klein-Gordon & Dirac eqs. in GR
- Thermodynamics of black holes and Hawking radiation
- Topics in gravitational waves: GW generation by PN sources, GW from elliptic, hyperbolic binaries
- Tests of the equivalence principle

Effective Field Theories for Particle Physics

Abstract
The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. These topics will be discussed both in general terms and with specific phenomenological applications in the context of physics beyond the Standard Model, effective description of the weak interaction, as well as the description of non-perturbative strong interaction at low energies.

Objective
This course covers the basic concepts of effective field theories (EFTs) and dispersion theory. We will start by introducing the core concept of constructing EFTs and apply them to the low-energy description of the weak interaction and the effective description of heavy physics beyond the Standard Model.

In the next part of the course, we will discuss Chiral Perturbation Theory (ChPT), the low-energy effective theory of Quantum Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

Content
- Introduction to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

Prerequisites / notice
QFT-I (mandatory) and QFT-II (highly recommended)

Scattering Amplitudes

Abstract
This course provides a pedagogical introduction to an advanced topic in Quantum Field Theories, which has undergone a tremendous progress in the new millennium: scattering amplitudes and on-shell methods.

Objective
Students that complete the course will be able to understand the basics of the modern methods to compute scattering amplitudes, to perform simple calculations and to read modern publications on this research field.

Special Students UZH must book the module PHY577 directly at UZH.

V. Del Duca
This course covers the basic concepts of:
-- spinor helicity formalism
-- colour decompositions
-- on-shell recursion relations
-- colour-kinematics duality
-- scattering equations
-- unitarity:
  * optical theorem
  * uniqueness of Yang-Mills
  * uniqueness of General Relativity
  * unitarity method
-- Feynman integrals, IBPs and differential equations
-- analytic and algebraic structure of loop-level amplitudes:
  * Hopf algebra, symbols and coproducts
  * multiple polylogarithms (a.k.a. as iterated integrals on the Riemann sphere)
  * elliptic and modular-form integrals (a.k.a. as iterated integrals on the torus)

This year we celebrate the tenth anniversary of the discovery of the Higgs boson. With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background and learn about the main experimental methods used to study the physics of the Higgs boson.

With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background to understand the main production and decay channels of the Higgs boson at high-energy colliders, and the corresponding experimental signatures.

Experimental part:
Introductory material:
- basics of accelerators and detectors
- reminders of statistics: likelihoods, hypothesis testing
- reminders of multivariate techniques: Boosted Decision Trees and Neural Networks
Main topics:
- pre-history (pre-LEP)
- LEP1: measurements at the Z-pole
- Electroweak constraints
- LEP2: towards the limit mH<114 GeV
- TeVatron searches
- LHC
  -- main channels overview
  -- dissect one analysis
  -- combine information from all channels
  -- differential measurements
  -- off-shell measurements

Content

402-0899-65L Higgs Physics  W 6 credits 2V+1U  M. Donegà, M. Grazzini

Lecture notes

402-0899-65L Higgs Physics

Abstract

Literature

- Higgs Hunter's Guide
  (by S.Dawson, J. Gunion, H. Haber and G. Kane)
- "Combination of Tevatron searches for the standard model Higgs boson in the W+W- decay mode" HWW TeVatron combination - http://arxiv.org/abs/1001.4162
- "Evidence for a particle produced in association with weak bosons and decaying to a bottom-antibottom quark pair in Higgs boson searches at the TeVatron" http://arxiv.org/abs/1207.6436
- "Precise determination of the mass of the Higgs boson and tests of compatibility of its couplings with the standard model predictions using proton collisions at 7 and 8 TeV" https://arxiv.org/abs/1412.8662
- "Measurements of the Higgs boson production and decay rates and constraints on its couplings with a combined ATLAS and CMS analysis of the LHC pp collision data at √s=7 and 8 TeV" https://arxiv.org/abs/1606.02266
- "Projections of Higgs Boson measurements with 30 fb at 8 TeV and 300 fb at 14 TeV" https://twiki.cern.ch/twiki/bin/view/CMSPublic/HiggsProjectionEsg2012TWiki

Prerequisites / notice

402-0899-65L Higgs Physics

Does not take place this semester.
String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- D-branes, T-duality
- supergravity as a low-energy effective theory, strings on curved backgrounds
- two-dimensional field theories (classical/quantum, conformal/non-conformal)

M.B. Green, J.H. Schwarz, E. Witten, Superstring Theory I, CUP (1987).

Recommended: Quantum Field Theory I (in parallel)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Objective</th>
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</thead>
<tbody>
<tr>
<td>402-0010-00L</td>
<td>Basics of Computing Environments for Scientists</td>
<td>Z</td>
<td>0</td>
<td>C. D. Herzog, C. Becker, S. Müller</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists.</td>
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<tr>
<td>Objective</td>
<td>The &quot;IT at D-PHYS&quot; introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.</td>
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<tr>
<td>Content</td>
<td>IT at D-PHYS (IT service providers and IT services at D-PHYS)</td>
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<tr>
<td>Modules</td>
<td>Linux Basics I (system components, basic shell usage)</td>
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<td>Linux Basics II (advanced tools, scripting)</td>
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<td>Python Ecosystem I (interpreters, packages, virtual environments)</td>
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<tr>
<td></td>
<td>Python Ecosystem II (development environments, formatter and linter, string formatting, regexp)</td>
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<td>System Aspects (how the hardware affects your scientific code and vice versa)</td>
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<tbody>
<tr>
<td>402-0620-00L</td>
<td>Current Topics in Accelerator Mass Spectrometry and Its Application</td>
<td>E-</td>
<td>0</td>
<td>M. Christl, S. Willett</td>
</tr>
<tr>
<td>Abstract</td>
<td>The seminar is aimed at all students who, during their studies, are confronted with age determination methods based on long-living radionuclides found in nature. Basic methodology, the latest developments, and special examples from a wide range of applications will be discussed.</td>
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<tr>
<td>Objective</td>
<td>The seminar provides the participants an overview about newest trends and developments of accelerator mass spectrometry (AMS) and related applications. In their talks and subsequent discussions the participants learn intensively about the newest trends in the field of AMS thus attaining a broad knowledge on both, the physical principles and the applications of AMS, which goes far beyond the horizon of their own studies.</td>
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<tbody>
<tr>
<td>376-1791-00L</td>
<td>Introductory Course in Neuroscience I (University of Zurich)</td>
<td>W</td>
<td>2</td>
<td>University lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.</td>
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<tr>
<td>Objective</td>
<td>The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.</td>
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</tbody>
</table>
1) Human Neuroanatomy I&II
2) Comparative Neuroanatomy
3) Building a central nervous system I,II
4) Synapses I,II
5) Glia and more
6) Excitability
7) Circuits underlying Emotion
8) Visual System
9) Auditory & Vestibular System
10) Somatosensory and Motor Systems
11) Learning in artificial and biological neural networks

Prerequisites / notice
For doctoral students of the Neuroscience Center Zurich (ZNZ).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days) Only for doctoral students.</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
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<tr>
<td>900-0101-DRL</td>
<td>Transferable Skills Course II (1-3 days) Only for doctoral students.</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
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<tr>
<td>900-0102-DRL</td>
<td>Transferable Skills Course III (1-3 days) Only for doctoral students.</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
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<tr>
<td>900-0103-DRL</td>
<td>Transferable Skills Course I (1-3 days, with Poster or Talk) Only for doctoral students.</td>
<td>W</td>
<td>2 credits</td>
<td>4S</td>
<td>Lecturers</td>
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<tr>
<td>900-0104-DRL</td>
<td>Transferable Skills Course II (1-3 days, with Poster or Talk) Only for doctoral students.</td>
<td>W</td>
<td>2 credits</td>
<td>4S</td>
<td>Lecturers</td>
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<tr>
<td>900-0105-DRL</td>
<td>Transferable Skills Course III (1-3 days, with Poster or Talk) Only for doctoral students.</td>
<td>W</td>
<td>2 credits</td>
<td>4S</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0106-DRL</td>
<td>Transferable Skills Course I (min 4 days) Only for doctoral students.</td>
<td>W</td>
<td>2 credits</td>
<td>4S</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Transferable Skills

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
Please select your doctoral thesis supervisor as a lecturer
and prove your participation with the appropriate
certificate.

<table>
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</thead>
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<tr>
<td>900-0107-DRL</td>
<td>Transferable Skills Course II (min 4 days)</td>
<td>W</td>
<td>2</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0108-DRL</td>
<td>Transferable Skills Course III (min 4 days)</td>
<td>W</td>
<td>2</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0109-DRL</td>
<td>Transferable Skills Course I (min 4 days, with Poster or Talk)</td>
<td>W</td>
<td>3</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0110-DRL</td>
<td>Transferable Skills Course II (min 4 days, with Poster or Talk)</td>
<td>W</td>
<td>3</td>
<td>Lecturers</td>
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<tr>
<td>900-0111-DRL</td>
<td>Transferable Skills Course III (min 4 days, with Poster or Talk)</td>
<td>W</td>
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<td>Lecturers</td>
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<tr>
<td>900-0112-DRL</td>
<td>Participation in Commission I (min 1 year)</td>
<td>W</td>
<td>1</td>
<td>Lecturers</td>
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<tr>
<td>900-0113-DRL</td>
<td>Participation in Commission II (min 1 year)</td>
<td>W</td>
<td>1</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0107-DRL
Transferable Skills Course II (min 4 days)
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0108-DRL
Transferable Skills Course III (min 4 days)
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0109-DRL
Transferable Skills Course I (min 4 days, with Poster or Talk)
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL
Transferable Skills Course II (min 4 days, with Poster or Talk)
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL
Transferable Skills Course III (min 4 days, with Poster or Talk)
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL
Participation in Commission I (min 1 year)
Only for doctoral students.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL
Participation in Commission II (min 1 year)
Only for doctoral students.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0114-DRL</td>
<td>Member of Executive Board (min 1 year)</td>
<td>W</td>
<td>2</td>
<td>4P</td>
<td>Lecturers</td>
</tr>
<tr>
<td></td>
<td>Only for doctoral students.</td>
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<td></td>
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<tr>
<td></td>
<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
<td>Active participation in the presidium or executive board of a university group for at least 1 year.</td>
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<tr>
<td>Objective</td>
<td>Active participation in the presidium or executive board of a university group for at least 1 year.</td>
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</tr>
<tr>
<td>851-0178-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students</td>
<td>W</td>
<td>1</td>
<td>2U</td>
<td>G. Achermann, E. Bobst, N. Gruber, E. Vayena</td>
</tr>
<tr>
<td></td>
<td>This course is interdisciplinary. If your department offers this course, please register there. The following departments offer this course in the fall semester 2022: D-BAUG, D-ERDW, MaP Doctoral School, D-USYS</td>
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<tr>
<td>Abstract</td>
<td>Doctoral students from D-GESS will have the opportunity to register for a discipline-specific course in spring semester 2023.</td>
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<tr>
<td>Objective</td>
<td>This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.</td>
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<tr>
<td>Content</td>
<td>Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>For doctoral students only.</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
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</tr>
<tr>
<td>851-0373-00L</td>
<td>Learning to Teach</td>
<td>W</td>
<td>2</td>
<td>2U</td>
<td>B. Volk, M. Lehner, S. Pedrocchi</td>
</tr>
<tr>
<td>Abstract</td>
<td>This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>This course imparts a variety of teaching skills which will help Doctoral Teaching Assistants with their teaching tasks.</td>
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</tr>
<tr>
<td>Content</td>
<td>In this course Doctoral Teaching Assistants will ...</td>
<td></td>
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<tr>
<td></td>
<td>• discuss learning science and teaching techniques with peers.</td>
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<tr>
<td></td>
<td>• design the introduction of their course/lecture/exercise class.</td>
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<td></td>
<td>• develop learning activities according to learning objectives.</td>
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<tr>
<td></td>
<td>• practice classroom assessment techniques in order to measure student learning.</td>
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<td></td>
<td>• engage in peer feedback in order to improve own teaching.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities (exercises, excursions, supervision of practicals, lectures, etc.) or those who will assume teaching tasks in the semester following the programme. No previous teacher training is required.</td>
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</tbody>
</table>

### Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0150-DRL</td>
<td>Summer School I (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2K</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39 Autumn Semester 2022
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Credit</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0151-DRL</td>
<td><strong>Summer School II (1-3 days)</strong></td>
<td>W 1 credit</td>
<td>2K</td>
</tr>
<tr>
<td>900-0152-DRL</td>
<td><strong>Summer School III (1-3 days)</strong></td>
<td>W 1 credit</td>
<td>2K</td>
</tr>
<tr>
<td>900-0153-DRL</td>
<td><strong>Summer School I (1-3 days, with Poster or Talk)</strong></td>
<td>W 2 credits</td>
<td>4K</td>
</tr>
<tr>
<td>900-0154-DRL</td>
<td><strong>Summer School II (1-3 days, with Poster or Talk)</strong></td>
<td>W 2 credits</td>
<td>4K</td>
</tr>
<tr>
<td>900-0155-DRL</td>
<td><strong>Summer School III (1-3 days, with Poster or Talk)</strong></td>
<td>W 2 credits</td>
<td>4K</td>
</tr>
<tr>
<td>900-0156-DRL</td>
<td><strong>Summer School I (min 4 days)</strong></td>
<td>W 2 credits</td>
<td>4K</td>
</tr>
<tr>
<td>900-0157-DRL</td>
<td><strong>Summer School II (min 4 days)</strong></td>
<td>W 2 credits</td>
<td>4K</td>
</tr>
<tr>
<td>900-0158-DRL</td>
<td><strong>Summer School III (min 4 days)</strong></td>
<td>W 2 credits</td>
<td>4K</td>
</tr>
<tr>
<td>900-0159-DRL</td>
<td><strong>Summer School I (min 4 days, with Poster or Talk)</strong></td>
<td>W 3 credits</td>
<td>6K</td>
</tr>
</tbody>
</table>
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### Abstract
- Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

### Objective
- Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Description</th>
<th>Credits</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0160-DRL</td>
<td>Summer School II (min 4 days, with Poster or Talk) Only for doctoral students.</td>
<td>3</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0161-DRL</td>
<td>Summer School III (min 4 days, with Poster or Talk) Only for doctoral students.</td>
<td>3</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0162-DRL</td>
<td>External Conference I (incl. Poster or Talk) Only for doctoral students.</td>
<td>1</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0163-DRL</td>
<td>External Conference II (incl. Poster or Talk) Only for doctoral students.</td>
<td>1</td>
<td>Lecturers</td>
</tr>
<tr>
<td>900-0164-DRL</td>
<td>External Conference III (incl. Poster or Talk) Only for doctoral students.</td>
<td>1</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

**Doctorate Physics - Key for Type**

- W+ Eligible for credits and recommended
- W Eligible for credits
- E- Recommended, not eligible for credits
- Z Courses outside the curriculum
- Dr Suitable for doctorate
- O Compulsory

**Key for Hours**

- V lecture
- G lecture with exercise
- U exercise
- S seminar
- K colloquium
- P practical/laboratory course
- A independent project
- D diploma thesis
- R revision course / private study

**ECTS**

- European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Subject Specialisation

Graduate Programme in Plant Sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-4003-01L</td>
<td>Current Topics in Grassland Sciences (HS)</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>N. Buchmann</td>
</tr>
<tr>
<td>Abstract</td>
<td>Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.</td>
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</tbody>
</table>

| 551-0205-00L | Challenges in Plant Sciences | W    | 2    | 2K    | S. C. Zeeman, S. Mintchev, M. Paschke, B. Pfister, further lecturers |
| Number of participants limited to 40. |       |      |      |       | |
| Abstract | The colloquium “Challenges in Plant Sciences” is a core class of the Zurich-Basel Plant Science Center’s PhD program and the MSc module. The colloquium introduces participants to the broad spectrum of plant sciences within the network. The course offers the opportunity to approach interdisciplinary topics in the field of plant sciences. |       |      |       |
| Objective | Objectives of the colloquium are: |       |      |       |
| - Introduction to recent research in all fields of plant sciences |       |      |       |
| - Working in interdisciplinary teams on the topics |       |      |       |
| - Developing presentation and discussion skills |       |      |       |
| Content  | The topics encompass integrated knowledge on current plant research, ranging from the molecular level to the ecosystem level, and from basic to applied science while making use of the synergies between the different research groups within the PSC. More information on the content: https://www.plantsciences.uzh.ch/en/teaching/masters/colloquium.html |       |      |       |

Environmental Sciences

Atmosphere and Climate

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1239-00L</td>
<td>Aerosols I: Physical and Chemical Principles</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>M. Gysel Beer, D. Bell, E. Weingartner</td>
</tr>
<tr>
<td>Abstract</td>
<td>Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.</td>
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<tr>
<td>Objective</td>
<td>The students...</td>
<td></td>
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</tr>
<tr>
<td>- know the processes and physical laws of aerosol dynamics.</td>
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<tr>
<td>- understand the thermodynamics of phase equilibria and chemical equilibria.</td>
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<tr>
<td>- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.</td>
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<tr>
<td>Experimental methods:</td>
<td>The students...</td>
<td></td>
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<tr>
<td>- know the most important chemical and physical measurement instruments.</td>
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<tr>
<td>- understand the underlying chemistry and physics.</td>
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</tr>
<tr>
<td>Environmental impacts:</td>
<td>The students...</td>
<td></td>
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</tr>
<tr>
<td>- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.</td>
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<tr>
<td>- know the most important climate impacts of atmospheric aerosols.</td>
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<tr>
<td>are aware of the health impacts of atmospheric aerosols.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>materiel is distributed during the lecture</td>
<td></td>
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</tr>
</tbody>
</table>
701-1235-00L Cloud Microphysics 

**Abstract**
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes. The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

**Objective**
The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles and: https://moodle-app2.let.ethz.ch/course/view.php?id=15424

**Content**
Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

**Lecture notes**
Documentation and supporting material:
- slides used during the lecture
- exercise sets and solutions
- R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

**Literature**
For complementary reading:

**Prerequisites / notice**
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik V: Angewandte Statistik fur Umwelt Naturwissenschaften (701-0155-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

**701-1253-00L Analysis of Climate and Weather Data**

**Abstract**
An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis.

Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.

**Objective**
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.

**Content**
The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

**Lecture notes**
Documentation and supporting material:
- slides used during the lecture
- exercise sets and solutions
- R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

**Literature**
For complementary reading:

**Prerequisites / notice**
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik V: Angewandte Statistik fur Umwelt Naturwissenschaften (701-0155-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.
Prerequisites / notice

Taught competencies

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

701-1221-00L Dynamics of Large-Scale Atmospheric Flow

Abstract
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Objective
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

Content
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes
Dynamics of large-scale atmospheric flow

Literature
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

701-1251-00L Land-Climate Dynamics

Abstract
The target groups are the following:
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.

Objective
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

Content
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Powerpoint slides will be made available

Prerequisites / notice
Prerequisites: Introductory lectures in atmospheric and climate science

701-1233-00L Stratospheric Chemistry

Abstract
The lecture gives an overview of the manifold reactions which occur in the gas phase, in stratospheric aerosol droplets and in polar cloud particles. The focus is on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.

Objective
The students will understand the gas phase reactions in the stratosphere as well as reactions and processes in aerosol droplets and polar stratospheric clouds.

Content
The students will understand the most important aspects of stratospheric dynamics and the greenhouse gas effect in troposphere and stratosphere.

Lecture notes
Documents are provided in the contact hours.

Literature

Prerequisites / notice
Prerequisites: Basics in physical chemistry are required and an overview equivalent to the bachelor course in atmospheric chemistry (lecture 701-0471-01) is expected.

701-1211-01L Master's Seminar: Atmosphere and Climate 1

Target groups only:
Master Environmental Science
Master Atmospheric and Climate Science

Abstract
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Objective
Training scientific writing skills.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 816 of 2345
Content
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Prerequisites / notice
Attendance is mandatory.

651-4095-00L Colloquium Atmosphere and Climate 1

Abstract
The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

Objective
The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

Biogeochemistry and Pollutant Dynamics

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
701-1313-00L | Isotopes and Biomarkers in Biogeochemistry | W | 3 credits | 2G | C. Schubert, N. Casacuberta Arola, R. Kipfer
701-1313-00L | Biogeochemistry of Trace Elements | W | 3 credits | 2G | A. Voegelin, S. Bouchet, L. Winkel
701-1315-00L | Carbon Mitigation | W | 3 credits | 2G | N. Gruber
701-1315-00L | Cooperation and Conflict Over International Water Resources | W | 3 credits | 2G | T. Bernauer, T. U. Siegfried
This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

### Objective
- Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

### Content
The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.Sep</td>
<td>Global water challenges</td>
</tr>
<tr>
<td>27.Sep</td>
<td>Nuts and bolts of hydrological modeling and what such models can tell us</td>
</tr>
<tr>
<td>04.Oct</td>
<td>Nuts and bolts of hydrological modeling and what such models can tell us</td>
</tr>
<tr>
<td>11.Oct</td>
<td>Water pollution and its mitigation</td>
</tr>
<tr>
<td>18.Oct</td>
<td>Key challenges in international river systems</td>
</tr>
<tr>
<td>25.Oct</td>
<td>Key challenges in international river systems</td>
</tr>
<tr>
<td>01.Nov</td>
<td>Case study 1: Yarmuk</td>
</tr>
<tr>
<td>08.Nov</td>
<td>Case study 2: Mekong</td>
</tr>
<tr>
<td>15.Nov</td>
<td>Case study 3: Colorado</td>
</tr>
<tr>
<td>22.Nov</td>
<td>Case study 4: Nile</td>
</tr>
<tr>
<td>29.Nov</td>
<td>Case study 5: Central Asia</td>
</tr>
<tr>
<td>06.Dec</td>
<td>Wrap up: what we can learn from these case studies</td>
</tr>
<tr>
<td>13.Dec</td>
<td>Exam</td>
</tr>
<tr>
<td>20.Dec</td>
<td>No class</td>
</tr>
</tbody>
</table>

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

### Literature
- Slides and reading materials will be made available via Moodle.
- Additional documents are handed out as copies.

### Prerequisites / Notice
- Limited to 40 students.
- The course is open to Master and doctoral students from any area of ETH.

#### Ecology and Evolution

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
</tbody>
</table>

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

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

**Content**
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans. Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.

#### Ecological Assessment and Evaluation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1453-00L</td>
<td>Ecological Assessment and Evaluation</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>F. Knaus</td>
</tr>
</tbody>
</table>

**Abstract**
The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

**Objective**
- Students will be able to:
  1. critically consider biological data books and local, regional, and national inventories;
  2. evaluate the validity of ecological criteria used in decision making processes;
  3. critically appraise the handling of ecological data and criteria used in the process of evaluation;
  4. perform an ecological evaluation project from the field survey up to the decision making and planning.

**Lecture notes**
Powerpoint slides are available on the webpage. Additional documents are handed out as copies.

**Literature**
Basic literature and references are listed on the webpage.

#### Research Seminar: Ecological Genetics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1409-00L</td>
<td>Research Seminar: Ecological Genetics</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>S. Fior</td>
</tr>
</tbody>
</table>

**Minimum number of participants is 5.**

**Objective**
It is our aim that participants gain insight into current research topics and approaches in Ecological Genetics and learn to critically assess and appreciate scientific publications in this field.

**Lecture notes**
Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course.

- It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).
Getting familiar with scientific arguments and discussions. Overview of current research topics. Making contacts with fellow students in...
To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To analyze the evolution as well as the key elements of environmental governance.

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

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

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

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

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

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

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

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

Objective

- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content

Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies.

The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes

Reader with issue-specific articles. E-version is partly available on Moodle
Literature
Aerni, P. (2021a) 'The ethics of farm animal biotechnology from an anthropological perspective'. Sustainability 13(7), 3674.

Aerni, P. (2021b) 'Decentralized economic ecosystems in Switzerland and their contribution to inclusive and sustainable change'. Sustainability 13(8), 4181


Aerni, P. (2021e) "Business as Part of the Solution": SDG 8 Challenges Popular Views in the Global Sustainability Dis-course'. MPDI Book Series on Transitioning toward Sustainability. 67-101.

Aerni, P. 2018 'Global Business in Local Culture: The Impact of Embedded Multinational Enterprises'. Springer

Aerni, P. 2016a. Coping with Migration-Induced Urban Growth: Addressing the Blind Spot of UN Habitat. Sustainability 8(800)


Romer, P. 2020. What It Takes To Be a Leader in Both Basic Science and Technological Progress. Statement for House Budget Committee Hearing on Federal R&D (https://paulromer.net/statement-for-house-budget-committee/)


Prerequisites / notice
The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester.

The class will be taught in English.

Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

701-1551-00L Sustainability Assessment W 3 credits 2G P. Krüttli, D. Nef

Does not take place this semester.

Number of participants is limited to 35.

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

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

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

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

Lecture notes
Handouts are provided

Literature
Selected scientific articles and book-chapters

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

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Communication not assessed
Cooperation and Teamwork not assessed
Creative Thinking not assessed
Critical Thinking assessed

Social Competencies
Cooperation and Teamwork

Personal Competencies

In Autumn Semester 2022

Forest and Landscape Management

Number Title Type ECTS Hours Lecturers
701-1631-00L Foundations of Ecosystem Management W 5 credits 3G J. Ghazoul, A. Giger Dray

Number of participants is limited to 35.

Priority is given to the target groups until 26.09.2022,

Target groups

MAS ETH in Raumplanung
MAS ETH in Sustainable Water Resources
Science, Technology and Policy MSc
Environmental Sciences MSc

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This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

Students should be able to:

- a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
- b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

Environmental Governance
Number of participants is limited to 30.

Waiting list will be deleted on 30.09.2022

Target groups:
- Environmental Sciences MSc
- Agricultural Sciences MSc

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

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

To analyze the evolution as well as the key elements of environmental governance.

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

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

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

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

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.
Communication
Handouts will be available on the webpage of the course.

Creative Thinking
Lecture notes, exercises and worked out solutions to them will be provided.

Geographic Data Processing with Python and ArcGIS, N. Buchmann, R. A. Werner, A. Gessler, M. Lehmann

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

Analytical Competencies
Critical Thinking

Self-presentation and Social Influence
Self-awareness and Self-reflection
Self-direction and Self-management

Method-specific Competencies
Techniques and Technologies

Social Competencies
Communication

Personal Competencies
Adaptability and Flexibility

Concepts and Theories

Taught competencies

Subject-specific Competencies

751-5125-00L

Stable Isotope Ecology of Terrestrial Ecosystems

Number of participants limited to 20.

701-1776-00L

Geographic Data Processing with Python and ArcGIS

Number of participants limited to 30.

102-0675-00L

Earth Observation

Abstract

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

Objective

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

Content

Die Lehrveranstaltung gibt einen Einblick in die heutige Erdbeschäftigung mit dem folgenden skizzierten Inhalt:

1. Einführung in die Fernerkundung von Luft- und Weltraum gestützten Systemen
2. Einführung in das Elektromagnetische Spektrum
3. Einführung in optische Systeme (optisch und hyperspektral)
4. Einführung in Mikrowellen-Technik (akтив und passiv)
5. Einführung in atmosphärische Systeme (meteo und chemisch)
6. Einführung in die Techniken und Methoden zur Bestimmung von Umweltparametern
7. Einführung in die Anwendungen zur Bestimmung von Umweltparametern in der Hydrologie, Glaziologie, Forst und Landwirtschaft, Geologie und Topographie

Lecture notes

Folien zu jedem Vorlesungsblock werden zur Verfügung gestellt.

Literature

Ausgewählte Literatur wird am Anfang der Vorlesung vorgestellt.

701-1776-00L

Geographic Data Processing with Python and ArcGIS

1 credit

2U

A. Baltensweiler

Abstract

The course communicates the basics of the programming language Python and gives a general introduction into the geoprocessing framework of ArcGIS. In addition various Python libraries (numpy, Scipy, GDAL, statsmodels, pandas, Jupyter Notebook) will be introduced which increase the functional range of the geoprocessing framework substantially.

Objective

The students learn the basics of geographic data processing based on the programming language Python and ArcGIS (arcpy). They get the ability to implement their own processing sequences and models for geoprocessing. The students are able to integrate open source libraries in their Python scripts and know how the libraries are applied to spatial datasets.

Content

The course communicates a deepened understanding of the geoprocessing frameworks arcpy and covers basic language concepts of Python such as datatypes, control structures and functions. In addition the application of popular Python libraries in combination with spatial datasets will be shown.

Lecture notes

Lecture notes, exercises and worked out solutions to them will be provided.
Lecture notes (in English) will be handed out in the class.

The students...

Dendroecology

Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can

- Overview and history of dendrochronology
  
- Principles of dendrochronology
- Formation and structure of wood and tree rings
- Wood anatomy and intra-seasonal tree-ring growth
- Continuous and discontinuous tree-ring characteristics
- Sampling and measuring of tree rings
- Crossdating methods (visual, skeleton plots, quantitative)
- Detrending and standardization of tree-ring series
- Development of tree-ring chronologies
- Water transport in trees
- Stable isotopes in tree rings
- Climate influences, climate-growth relationships, climate reconstructions
- Reconstruction of forest dynamics (regeneration, growth, competition, mortality)
- Disturbance ecology (fire, insects, blowdown)
- Application of tree-ring research in practice and in interdisciplinary research projects
- Field and lab day (date for one entire day or two half days will be searched together with the students in the beginning of the semester): discussion of different dendroecological questions in the forest; sampling of trees; insight into different tree-ring projects in the lab (Swiss Federal Institute for Forest, Snow and Landscape Research WSL)

Lecture notes

Lecture notes (in English) will be handed out in the class.

Literature


Prerequisites / notice

Basic knowledge of ArcGIS is assumed.

<table>
<thead>
<tr>
<th>701-1682-00L</th>
<th>Dendroecology</th>
<th>W</th>
<th>3 credits</th>
<th>3G</th>
<th>C. Bigler, K. Treydte, G. von Arx</th>
</tr>
</thead>
</table>

Abstract

The course dendroecology offers theoretical and practical aspects of dendrochronology. The impact of different environmental influences on tree-ring characteristics will be shown. The students learn various methods to date tree rings and they understand how ecological and environmental processes and patterns can be reconstructed using tree rings.

Objective

The students...

- understand, how wood is configured and how tree-ring structures are formed.
- are able to identify and describe different tree-ring structures.
- understand the theoretical and practical aspects of the dating of tree rings.
- know the effects of different abiotic and biotic environmental influences (climate, site, competition, insects, fire, physical-mechanical influences) on trees and tree rings.
- discover a tool for understanding and reconstructing global change processes.
- learn software to date, standardize and analyze tree rings.
- get hands-on experience based on the demonstration of wood (increment cores, stem discs, wedges), sampling in the field, and measuring and dating of tree rings in the tree-ring lab.
- solve R-based exercises (R tutorial will be provided) and answer questions in Moodle.
- work out an independent research question related to a dendroecological topic and write a short literature review based on scientific papers.

Content

- Overview and history of dendrochronology
- Principles of dendrochronology
- Formation and structure of wood and tree rings
- Wood anatomy and intra-seasonal tree-ring growth
- Continuous and discontinuous tree-ring characteristics
- Sampling and measuring of tree rings
- Crossdating methods (visual, skeleton plots, quantitative)
- Detrending and standardization of tree-ring series
- Development of tree-ring chronologies
- Water transport in trees
- Stable isotopes in tree rings
- Climate influences, climate-growth relationships, climate reconstructions
- Reconstruction of forest dynamics (regeneration, growth, competition, mortality)
- Disturbance ecology (fire, insects, blowdown)
- Application of tree-ring research in practice and in interdisciplinary research projects
- Field and lab day (date for one entire day or two half days will be searched together with the students in the beginning of the semester): discussion of different dendroecological questions in the forest; sampling of trees; insight into different tree-ring projects in the lab (Swiss Federal Institute for Forest, Snow and Landscape Research WSL)

Lecture notes

Lecture notes (in English) will be handed out in the class.

Literature

The lecture notes and further documents (papers, software) can be downloaded from Moodle (https://moodle-app2.let.ethz.ch) following registration for the course.

Prerequisites / notice

Time schedule (total of 90 hours): There will be 12 lectures with each two hours (total of 24 hours presence) as well as a field and lab day (8 hours presence). In addition, the students are expected to put 18 hours into the preparation of the lectures as well as 18 hours for the exercises. 4 hours are reserved for the lab work and 18 hours for the project.

The class language is German and English, on request English only.

Requirements:

Basics of biology, ecology and forest ecology

<table>
<thead>
<tr>
<th>701-1695-00L</th>
<th>Soil Science Seminar</th>
<th>Z</th>
<th>0 credits</th>
<th>1S</th>
<th>R. Kretzschmar, A. Carminati, S. Dötterl, E. Frossard, M. Hartmann</th>
</tr>
</thead>
</table>

Abstract

Invited external speakers present their research on current issues in the field of soil science and discuss their results with the participants.

Objective

Master and PhD students are introduced to current areas of research in soil sciences and get first-hand experience in scientific discussion.

Inter- and Transdisciplinary Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0015-00L</td>
<td>Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>B. Vienni Baptista, C. E. Pohl, M. Stauffacher</td>
</tr>
</tbody>
</table>

Abstract

This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants‘ research projects more societally relevant.

Objective

Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content

The seminar covers the following topics:

1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants‘ research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.
Literature will be made available to the participants. The following open access article builds a core element of the course:


available at (open access): http://www.ingentaconnect.com/content/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used:

https://naturalsciences.ch/topics/co-producing_knowledge

Prerequisites / notice

Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, November 9, November 23, November

Taught competencies

Subject-specific Competencies
Concepts and Theories
Problem-solving

Method-specific Competencies

Social Competencies
Cooperation and Teamwork
Sensitivity to Diversity

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection

Not assessed

Basic and Scientific Skills

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<tr>
<td>701-0019-00L</td>
<td>Readings in Environmental Thinking</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>J. Ghazoul</td>
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Number of participants limited to 20.

Waiting list will be deleted 30.09.2022.

Abstract

This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance, and shaped its relevance to society. Above all, the course seeks to give confidence and raise enthusiasm among students to read more widely around the broad subject of environmental sciences and management both during the course and beyond.

Objective

The course will provide students with opportunities to read, discuss, evaluate and interpret key texts that have shaped the environmental movement and, more specifically, the environmental sciences. Students will gain familiarity with the foundational texts, but also understand the historical context within which their academic and future professional work is based. More directly, the course will encourage debate and discussion of each text that is studied, from both the original context as well as the modern context. In so doing students will be forced to consider and justify the current societal relevance of their work.

Content

The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is, E. J. Harris, J. Payne, Psychology of Nature). Readings in Environmental Thinking: An Introduction. London: Earthscan. Students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer. Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

The specific texts selected for discussion will vary, but examples include:

Leopold (1949) A Sand County Almanach
Carson (1962) Silent Spring
Jared Diamond (2005) Collapse

Discussions might also encompass films or other forms of media and communication about nature.

Number of participants is limited to 80.

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

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

Waiting list will be deleted 30.09.2022

Abstract

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

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

Content

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

Prerequisites / notice

252-0840-02L Anwendungsnahe Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

Research Ethics

851-0180-00L

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<th>W</th>
<th>2 credits</th>
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<th>G. Achermann, P. Emch</th>
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 Particularly suitable for students of D-BIOL, D-CHAB, D-HEST

Abstract

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective

Participants of the course Research Ethics will:
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
- Critically think about the limits and implications of a method
- Visualise data and results throughout the workflow
- Access online resources to keep up with the latest data science methodology and deepen their understanding

Content

I. Introduction to Moral Reasoning

1. Ethics - the basics
   1.1 What ethics is not...
   1.2 Recognising an ethical issue (awareness)
   1.3 What is ethics? Personal, cultural and ethical values, principles and norms
   1.4 Ethics: a classification
   1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
   2.1 What is normative ethics?
   2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories
   2.3 The plurality of normative theories (moral pluralism);
   2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
   3.1 How (not) to approach ethical issues
   3.2 What is a moral dilemma? Is there a correct method for answering moral questions?
   3.3 Methods of making ethical decisions

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
   1.1 What is research integrity and why is it important?
   1.2 What is research misconduct?
   1.3 Questionable/Detrimental Research Practice (QRP/DRP)
   1.4 What is the incidence of misconduct?
   1.5 What are the factors that lead to misconduct?
   1.6 Responding to research wrongdoing
   1.7 The process of dealing with misconduct
   1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
   2.1 Data collection and recordkeeping
   2.2 Analysis and selection of data
   2.3 The (mis)representation of data
   2.4 Ownership of data
   2.5 Retention of data
   2.6 Sharing of data (open research data)
   2.7 The ethics of big data

3. Publication ethics / Responsible publishing
   3.1 Background
   3.2 Criterias for being an author
   3.3 Ordering of authors
   3.4 Publication practices

III. Research Ethics – External responsibilities

1. Research involving human subjects
   1.1 History of research with human subjects
   1.2 Basic ethical principles – The Belmont Report
   1.3 Requirements to make clinical research ethical
   1.4 Social value and scientific validity
   1.5 Selection of study participants – the concept of vulnerability
   1.6 Favourable risk-benefit ratio

2. Social responsibility
   2.1 What is social responsibility?
   2.2 Participation in public discussions

3. Dual use research
   3.1 Introduction to Dual use research

Lecture notes

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 826 of 2345
Prerequisites / notice

What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):

1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...).

Taught competencies

Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Decision-making
Problem-solving

Method-specific Competencies
Communication
Cooperation and Teamwork

Social Competencies
Creative Thinking

Personal Competencies
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

Transferable Skills

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<td>Ethics and Scientific Integrity for Doctoral Students of D-USYS</td>
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<td>N. Gruber, A. Widmer</td>
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Abstract
This course sensitises doctoral students to ethical issues that may arise during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students are given the opportunity to apply their knowledge and train their newly acquired skills in an interactive, discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. Furthermore, they are encouraged to reflect on their professional role as scientific researchers.

Content
Part I
The self-paced e-learning course consists of 5 modules:

Module 1: Ethics
Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices or solve ethical dilemmas).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects in the general area of Environmental Sciences. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only

Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Decision-making
Problem-solving

Method-specific Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

900-0100-DRL Transferable Skills Course I (1-3 days) W 1 credit 2S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0101-DRL Transferable Skills Course II (1-3 days) W 1 credit 2S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
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**Abstract**: Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Objective**: Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

*Only for doctoral students.*
Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL
Transferable Skills Course II (min 4 days, with Poster or Talk)
W 3 credits 6S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL
Transferable Skills Course III (min 4 days, with Poster or Talk)
W 3 credits 6S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL
Participation in Commission I (min 1 year)
W 1 credit 2P Lecturers
Only for doctoral students.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL
Participation in Commission II (min 1 year)
W 1 credit 2P Lecturers
Only for doctoral students.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL
Member of Executive Board (min 1 year)
W 2 credits 4P Lecturers
Only for doctoral students.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective
Educational Science for Teaching Diploma and TC

Integration into Scientific Community

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Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0151-DRL
Summer School II (1-3 days)
W 1 credit 2K Lecturers
Only for doctoral students.

Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0152-DRL
Summer School III (1-3 days)
W 1 credit 2K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer
and prove your participation with the appropriate certificate.

### Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

### Objective
Participation in summer or winter schools with a maximum duration of 3 days.

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<td>Participation in summer or winter schools with a minimum duration of 4 days.</td>
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<td>W</td>
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<td>6K</td>
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<td></td>
<td>Only for doctoral students</td>
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<td>Please select your doctoral thesis supervisor as a lecturer</td>
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<td>and prove your participation with the appropriate certificate</td>
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</tbody>
</table>
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

<table>
<thead>
<tr>
<th>Code</th>
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<td>External Conference II (incl. Poster or Talk)</td>
<td>W</td>
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Doctorate Environmental Sciences - Key for Type

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<th>Key</th>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
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<td>O</td>
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Key for Hours

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<tr>
<td>V</td>
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<td>G</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Electrical Engineering and Information Technology Bachelor

#### 1st Semester

##### First Year Examinations

#### First Year Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>227-0003-00L</td>
<td>Digital Circuits</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>M. Luisier</td>
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<tr>
<td>Abstract</td>
<td>Digital and analogue signals and their representation, logic gates, transistors, combinational and sequential circuits and systems, boolean algebra, Karnaugh-maps, finite state machines, memory and computing building blocks in CMOS technology.</td>
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<tr>
<td>Objective</td>
<td>Provide basic knowledge and methods to understand and to design digital circuits and systems.</td>
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<td>Digital and analogue signals and their representation. Boolean Algebra, circuit analysis and synthesis, the MOS transistor, CMOS logic, static and dynamic behaviour, Karnaugh-Maps, hazards, binary number systems, coding. Combinational and sequential circuits and systems (boolean algebra, K-maps, etc.). Memory building blocks and memory structures, programmable logic circuits. Finite state machines, architecture of microprocessors.</td>
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<td>Lecture notes for all lessons, assignments and solutions.</td>
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<td></td>
<td>Decision-making</td>
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<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>401-0151-00L</td>
<td>Linear Algebra</td>
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<td>5 credits</td>
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<td>V. C. Gradinaru</td>
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<td>Abstract</td>
<td>Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.</td>
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<td>Objective</td>
<td>Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte</td>
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<tr>
<td>Lecture notes</td>
<td>eigenes Aufschrieb und K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002</td>
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<td>K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002</td>
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<td>Cooperation and Teamwork</td>
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<td>227-0001-00L</td>
<td>Networks and Circuits I</td>
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<td>2V+2U</td>
<td>C. Franck</td>
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<td>Abstract</td>
<td>This course introduces the students into the basics of electric circuits, the underlying physical phenomena and required mathematical methods.</td>
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<td>Objective</td>
<td>Voltage, current and properties of basic elements of electric circuits, i.e. capacitors, resistors and inductors should be understood in relation to electric and magnetic fields. Furthermore, the students should be able to mathematically describe, analyze and finally design technical realizations of circuit elements. Students should also be familiar with the calculation of voltage and current distributions of DC circuits. The effect and the mathematical formulation of magnetic induction should be known for technical applications.</td>
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<tr>
<td>Content</td>
<td>Electrostatic field; Stationary electric current flow; Basic electric circuits; current conduction mechanisms; time variant electromagnetic field.</td>
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<tr>
<td>Lecture notes</td>
<td>Manfred Albach, Elekrotechnik ISBN 978-3-86894-398-6 (2020) and lecture notes</td>
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Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Concepts and Theories
- assessed
- not assessed

Techniques and Technologies
- assessed
- not assessed

Analytical Competencies
- not assessed

Decision-making
- not assessed

Media and Digital Technologies
- not assessed

Problem-solving
- not assessed

Project Management
- not assessed

Communication
- not assessed

Cooperation and Teamwork
- not assessed

Customer Orientation
- not assessed

Leadership and Responsibility
- not assessed

Self-presentation and Social Influence
- not assessed

Sensitivity to Diversity
- not assessed

Negotiation
- not assessed

Adaptability and Flexibility
- not assessed

Creative Thinking
- not assessed

Critical Thinking
- not assessed

Integrity and Work Ethics
- not assessed

Self-awareness and Self-reflection
- not assessed

Self-direction and Self-management
- not assessed

151-0223-10L Engineering Mechanics
- 4 credits
- 2V+2U+1K
- P. Tiso

Abstract
Introduction to engineering mechanics: kinematics, statics and dynamics of rigid bodies and systems of rigid bodies.

Objective
Students can solve problems of elementary engineering mechanics.

Content
Basic notions: position and velocity of particles, rigid bodies, planar motion, kinematics of rigid body, force, couple, power. Statics: static equivalence, force-couple system, center of forces, centroid, principle of virtual power, equilibrium, constraints, statics, friction. Dynamics: acceleration, inertial forces, d'Alembert's Principle, Newton's Second Law, principles of linear and angular momentum, equations of planar motion of rigid bodies.

Lecture notes
yes, in German

Literature

First Year Examination Block B

Number Title Type ECTS Hours Lecturers
401-0231-10L Analysis 1 O 8 credits 4V+3U T. Rivière

Students in BSc EEIT may instead register for 401-1261-07L Analysis I: One Variable (for BSc Mathematics, BSc Physics and BSc Interdisciplinary Science (Phys Chem)) and take the performance assessment of the corresponding two-semester course. Students in BSc EEIT who wish to register for 401-1261-07L/401-1262-07L Analysis I: One Variable/Analysis II: Several Variables instead of 401-0231-10L/401-0232-10L Analysis I/Analysis 2 must get in touch with the Study Administration before the registration.

Abstract
Reelle und komplexe Zahlen, Grenzwerte, Folgen, Reihen, Potenzreihen, stetige Abbildungen, Differential- und Integralrechnung einer Variablen, Einführung in gewöhnliche Differentialgleichungen

Objective
Einführung in die Grundlagen der Analysis

Lecture notes
Christian Blatter: Ingenieur-Analysis (Kapitel 1-4)

Literature
Konrad Koenigsberger, Analysis I.
Christian Blatter, Analysis I.

First Year Compulsory Laboratory Courses

Number Title Type ECTS Hours Lecturers
227-0005-10L Digital Circuits Laboratory O 1 credit 1P A. Emboras, M. Luisier

Abstract
Digital and analogue signals and their representation. Combinational and sequential circuits and systems, boolean algebra, Karnaugh-maps. Finite state machines. Memory and computing building blocks in CMOS technology, programmable logic circuits.

Objective
Deepen and extend the knowledge from lecture and exercises, usage of design software Quartus II as well as an oscilloscope

Content
The contents of the digital circuits laboratory will deepen and extend the knowledge of the correspondent lecture and exercises. With the help of the logic device design software Quartus II different circuits will be designed and then tested on an evaluation board. You will build up the control for a 7-digit display as well as an adder and you will create different types of latches and flip-flops. At the end of the laboratory a small synthesizer will be programmed that is able to play self-created melodies. At the same time the usage of a modern oscilloscope will be taught in order to analyse the programmed circuits through the digital and analogue inputs.

Lecture notes
Lecture notes for all experiments.
https://iis-students.ee.ethz.ch/lectures/digital-circuits/praktikum/

Prerequisites / notice
No special prerequisites
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed

Preparatory Course in Computer Science

<table>
<thead>
<tr>
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<td>Preparatory Course in Computer Science</td>
<td>O</td>
<td>1 credit</td>
<td>1P</td>
<td>M. Schwerhoff</td>
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</table>

Abstract
The course provides an elementary introduction to programming with C++. Prior programming experience is not required.

Objective
Establish an understanding of basic concepts of imperative programming and how to systematically approach programming problems. Students are able to read and write simple C++ programs.

Content
This course introduces you to the basics of programming with C++. Programming means instructing a computer to execute a series of commands that ultimately solve a particular problem.

The course comprises the following:
- General introduction to computer science: development, goals, fundamental concepts
- Interactive self-study tutorial that provides an introduction to C++ and covers the following topics: variables, data types, conditional statements and loops
- Introduction to stepwise refinement as an approach to systematically solving programming problems
- Two small programming projects, to practically apply the studied fundamentals

Lecture notes
All teaching material is available online; an online development environment is used for the the programming projects.

3rd Semester: Examination Blocks

Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0353-00L</td>
<td>Analysis 3</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>M. Iacobelli</td>
</tr>
</tbody>
</table>

Abstract
In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

Objective
The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

Content
1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)
2.) Quasilinear first order PDEs
   - Solution with the method of characteristics
   - Conservation laws
3.) Hyperbolic PDEs
   - wave equation
   - d'Alembert formula in (1+1)-dimensions
   - method of separation of variables
4.) Parabolic PDEs
   - heat equation
   - maximum principle
   - method of separation of variables
5.) Elliptic PDEs
   - Laplace equation
   - maximum principle
   - method of separation of variables
   - variational method

Literature

Prerequisites / notice
Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

402-0053-00L    | Physics II | O    | 8 credits | 4V+2U   | J. Faist   |

Abstract
The goal of the Physics II class is an introduction to quantum mechanics.

Objective
To work effectively in many areas of modern engineering, such as renewable energy and nanotechnology, students must possess a basic understanding of quantum mechanics. The aim of this course is to provide this knowledge while making connections to applications of relevancy to engineers. After completing this course, students will understand the basic postulates of quantum mechanics and be able to apply mathematical methods for solving various problems including atoms, molecules, and solids. Additional examples from engineering disciplines will also be integrated.
Introductory lecture on electronic circuits. Transistor fundamentals, analysis and design of transistor based electronic circuits such as

**227-0045-00L** Signals and Systems I

**Abstract**

**Objective**
Introduction to mathematical signal processing and system theory.

**Content**

**Lecture notes**
Lecture notes (hand-written) will be distributed via the Moodle interface

**Literature**


**Prerequisites / notice**
Prerequisites: Physics I.

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**252-0836-00L** Computer Science II

**Abstract**
The course provides the foundations for the design and analysis of algorithms. Classical problems ranging from sorting up to problems on graphs are used to discuss common data structures, algorithms and algorithm design paradigms.

The course also comprises an introduction to parallel and concurrent programming.

**Objective**
An understanding of the analysis and design of fundamental and common algorithms and data structures. Knowledge regarding chances, problems and limits of parallel and concurrent programming.

**Content**
Data structures and algorithms: mathematical tools for the analysis of algorithms (asymptotic function growth, recurrence equations, recurrence trees), informal proofs of algorithm correctness (invariants and code transformation), design paradigms for the development of algorithms (induction, divide-and-conquer, backtracking and dynamic programming), classical algorithmic problems (searching, selection and sorting), data structures for different purposes (linked lists, hash tables, balanced search trees, heaps, union-find), further tools for runtime analysis (generating functions, amortized analysis). The relationship and tight coupling between algorithms and data structures is illustrated with graph algorithms (traversals, topological sort, closure, shortest paths, minimum spanning trees).

Parallel programming: structure of parallel architectures (multicore, vectorization, pipelining) concepts of parallel programming (Amdahl's and Gustavson's laws, task/data parallelism, scheduling), problems of concurrency (data races, bad interleavings, memory reordering), process synchronisation and communication in a shared memory system (mutual exclusion, semaphores, monitors, condition variables).

The concepts are underpinned with examples of concurrent and parallel programs and with parallel algorithms, implemented in C++.

In general, the concepts provided in the course are motivated and illustrated with practically relevant algorithms and applications.

Exercises are carried out in Code-Expert, an online IDE and exercise management system.

All required mathematical tools above high school level are covered, including a introduction to graph theory.

**Lecture notes**
tba

**Literature**


**Prerequisites / notice**
Prerequisite: Computer Science I

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**Examination Block 2**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0077-10L</td>
<td>Electronic Circuits</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>H. Wang</td>
</tr>
</tbody>
</table>

**Abstract**
Introductory lecture on electronic circuits. Transistor fundamentals, analysis and design of transistor based electronic circuits such as amplifiers and filters; operational amplifiers and circuits based thereon.

**Objective**
Modern, transistor-based electronics has transformed our lives and plays a crucial role in our economy since the 2nd half of last century. The main objective of this course in electronic circuits is to introduce the concept of the active device, including operational amplifiers, and their use in amplification, signal conditioning, switching and filtering to students. In addition to gaining experience with typical electronic circuits that are found in common applications, including their own Gruppenarbeit and Fachpraktikum projects, students sharpen their understanding of linear circuits based on nonlinear devices, imperfections of electronic circuits and the concept of design (as opposed to analysis). The course is a prerequisite for higher semester subjects such as analog integrated circuits, RF circuits for wireless communications, A/D and D/A converters and optoelectronics.

**Content**

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 835 of 2345
Modern, transistor-based electronics has transformed our lives and plays a crucial role in our economy since the 2nd half of last century. The main objective of this course in electronic circuits is to introduce the concept of active device, including operational amplifiers, and their use in amplification, signal conditioning, switching and filtering to students. In addition to gaining experience with typical electronic circuits that are found in common applications, including their own Gruppenarbeit and Fachpraktikum projects, students sharpen their understanding of linear circuits based on nonlinear devices, imperfections of electronic circuits and the concept of design (as opposed to analysis). The course is a prerequisite for higher semester subjects such as analog integrated circuits, RF circuits for wireless communications, A/D and D/A converters and optoelectronics.

Get to know and understand basic transistor and op amp based electronic circuits. Build and operate simple electronic circuits including supply decoupling. Carry out and understand different, principal measurement methods such as DC- and AC-analysis, time and frequency domain measurements, impedance and transfer function measurements. In the lab we will have a closer look at the following topics and circuits: characterization of a real capacitor including non-idealities; common-emitter transistor amplifier with emitter degeneration; characterization of a real operational amplifier with non-idealities; band pass filter with op amp, resistors and capacitors; data converters; oscillator and function generator based on an op amp.

### Laboratory Courses, Projects, Seminars

A minimum of 15 cp (under the 2018 regulations), respectively at least 18 cp (under the 2016 regulations) must be achieved in the category "Laboratory Courses, Projects, Seminars".

#### General Laboratory

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0095-10L</td>
<td>General Laboratory I</td>
<td>W</td>
<td>2 credits</td>
<td>2P</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Enrolment via Online-Tool (EE-Website: Studies -> Bachelor Program -> Third Year -> Laboratory Courses)

The Laboratory courses in the 5th and 6th semesters enable the students to put the the contents of the courses from the four first semesters to the test and to consolidate the acquired knowledge. Furthermore students have the possibility to gain specific knowledge in certain software packages as MATLAB.

#### Projects & Seminars

Enrolment is only possible for students in the BSc Electrical Engineering and Information Technology from Friday before the start of the semester. Places are allocated using the P&S application tool (https://psapp.ee.ethz.ch/). Please only enrol for P&S for which you apply via the tool.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0085-01L</td>
<td>Projects &amp; Seminars: Amateur Radio Course</td>
<td>W</td>
<td>1.5 credits</td>
<td>1P</td>
<td>J. Leuthold</td>
</tr>
</tbody>
</table>

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allowing for explorative learning and teaching the methodology of project work.

**Objective**

Game Development is a big field and is constantly growing. A powerful tool to create cross-platform games is Unity. Unity is a cross-platform real-time game engine that uses C# as its programming language (very similar to Java). This P&S is a great chance for gaining practical experience, creating something from scratch and establishing a supporting community. Therefore, if you are eager to improve your coding skills as well as bring them to life by applying them to game development, this is the right P&S for you!

**Abstract**

Projects & Seminars: Game Development with Unity

Does not take place this semester. Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Objective**

Simulation tools are becoming an essential accessory for scientists and engineers for the development of new devices and study of physical phenomena. More and more disciplines rely on accurate simulation tools to get insight and also to accurately design novel devices.

**Abstract**

Projects & Seminars: FPGA in Quantum Computing

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allowing for explorative learning and teaching the methodology of project work.

**Objective**

COMSOL is a powerful multiphysics simulation tool. It is used for a wide range of fields, including electromagnetics, semiconductors, thermodynamics and mechanics. In this P&S we will focus on the rapidly growing field of integrated photonics.

**Abstract**

Projects & Seminars: COMSOL Design Tool – Design of Optical Components

Does not take place this semester. Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Objective**

Microprocessors are used to execute big and generic applications, while microcontrollers are low cost and low power embedded chips with program memory and data memory built onto the system which are used to execute simple tasks within one specific application (i.e., sensor devices, wearable systems, and IoT devices). Microcontrollers demand very precise and resource-saving programming, therefore it is necessary to know the processor core, and particular importance has the investigation of the microcontroller’s hardware components (ADC, clocks, serial communication, timers, interrupts, etc.).

**Abstract**

Projects & Seminars: Microcontrollers for Sensors and Internet of Things

Does not take place this semester. Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Objective**

FPGA in Quantum Computing with Superconducting Qubits

Projects & Seminars: FPGA in Quantum Computing with Superconducting Qubits

Does not take place this semester. Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

**Objective**

The course will be taught in English.
FPGAs are used in a wide range of applications including video processing, machine learning, cryptography and radar signal processing. Thanks to their flexibility and massive parallel processing power, recently FPGAs have become important in quantum signal processing where high amount of data should be analyzed in a short time to use quantum setups most efficiently. In addition, FPGAs are used for quantum state detection and feedback generation, which have to be performed in the scale of hundreds of nanoseconds. The goal of this course is to understand the FPGA-based signal processing for superconducting circuits based quantum experiments. The course participants will learn the implementation techniques of the modules for fast quantum signal acquisition and processing, the electronics supporting quantum experiments, and FPGA programming. You will implement quantum signal processing and quantum state detection modules using Xilinx FPGA, Verilog HDL, and high speed ADC. The course will be taught in English. No prior knowledge in quantum physics or FPGA is required; still, a good knowledge in any coding language (for example C or Java) is required.

Projects & Seminars: Neural Network on Low Power FPGA: A Practical Approach

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
FPGAs are used in a wide range of applications including video processing, machine learning, cryptography, and radar signal processing, thanks to their flexibility and massive parallel processing power. Recently, FPGAs have become important in quantum signal processing where high amounts of data should be analyzed in a short time to use quantum setups most efficiently. In addition, FPGAs are used for quantum state detection and feedback generation, which have to be performed in the scale of hundreds of nanoseconds. The goal of this course is to understand the FPGA-based signal processing for superconducting circuits based quantum experiments. The course participants will learn the implementation techniques of the modules for fast quantum signal acquisition and processing, the electronics supporting quantum experiments, and FPGA programming. You will implement quantum signal processing and quantum state detection modules using Xilinx FPGA, Verilog HDL, and high speed ADC. The course will be taught in English. No prior knowledge in quantum physics or FPGA is required; still, a good knowledge in any coding language (for example C or Java) is required.

Projects & Seminars: Bluetooth Low Energy Programming for IoT Sensing System

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning, and teach the methodology of project work.

Objective
Artificial Intelligence and in particular neural networks are inspired by biological systems, such as the human brain. Through the combination of powerful computing resources and novel architectures for neurons, neural networks have achieved state-of-the-art results in many domains such as computer vision. FPGAs are one of the most powerful platforms to implement neural networks as they can handle different algorithms in computing, logic, and memory resources in the same device. Faster performance compared to competitive implementations as the user can hard-code operations into the hardware. This course will guide the student in Machine Learning to understand how they work and how they can be trained and giving hands-on experience with the training tools such as Keras. Moreover, the course will focus on deploying algorithms in low power FPGA such as the Lattice sensAI platform to have energy efficient running algorithms. The course will provide to the students the tools and know-how to implement neural network on an FPGA, and the student will challenge themselves in a 5 weeks practical project that they will present at the end of the course. Experience in FPGA programming is desirable but not mandatory.

Projects & Seminars: Spiking Neural Network on Neuromorphic Processors

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning, and teach the methodology of project work.

Objective
With the introduction of the BLE 5.0 standard, Bluetooth has achieved high data bandwidth with low power consumption. This makes the technology an ideal match for many applications, i.e., IoT sensor application or audio streaming, by addressing two of the greatest bottlenecks of these devices. This course offers the chance for participants to do hands-on programming of microcontrollers. In particular, the focus will be laid on interfacing with sensors, acquisition of data, on-board event-driven data processing with ARM-Cortex-M4 processors and BLE or other wireless transmissions. The programming will be performed in C. Today's microcontrollers offer a low power, efficient, and cost-effective solution of tackling a nearly infinite number of task-specific applications. Ranging from IoT devices, wearable systems, sensor (mesh) devices, all the way to be integrated as submodules for the most complex system such as cars, planes, and rockets. Microcontrollers derive their advantages from the efficient use of resources and as such require very efficient and resource-saving programming. Therefore, it is mandatory to understand hardware components such as processor cores, ADC, clocks, serial communication, wireless communication, timers, interrupts, etc. The P&S includes five weeks project where the student will setup an IoT sensor node to monitor electric power transmission and distribution system.

Projects & Seminars: Microcontroller Microcontroller

The course will be taught in English by the ITET center for project based learning.
Objective


Compared to the traditional artificial neural network, the spiking neural network (SNN) can provide both latency and energy efficiency. Moreover, SNN has demonstrated in previous works a better performance in processing physiological information of small sample size, and only the output layer of the spiking neural network needs to be trained, which results in a fast training rate. This course focuses on giving the bases of spiking neural networks and neuromorphic processors. Students will learn the tools to implement SNN algorithm in both academic processors and Intel Loihi using data from Event-based Vision camera and biomedical sensors (i.e. ECG and EEG). The course will end with 4 weeks project where the students can target a specific application scenario.

The course will be taught in English.

Projects & Seminars: Deep Learning for Image Manipulation (DLIM)

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective


With the advent of deep learning tremendous advances were achieved in numerous areas from computer vision, computer graphics, and image processing. Using these techniques, an image can be automatically manipulated in various ways with high-quality results, often fooling the human observer. Deep learning based image processing and manipulation are being applied in a vast number of emerging technologies, including image enhancement in smartphone cameras, automated image editing, image content creation, graphics, and autonomous driving. This course focuses on the fundamentals of deep learning and image manipulation. Students will learn the tools to implement and develop deep learning solutions for a variety of image manipulation tasks. The course will end with a 4 weeks project where the students can target a specific application scenario.

The course will be taught in English.

Projects & Seminars: Electronic Circuits & Signals Exploration Laboratory

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The goal of this lab course is for the students to enhance their understanding on how basic analog electronic circuits work, or perhaps don’t work, and provide enough practical experience for the students to feel at ease using transistors, resistors, capacitors, diodes, etc., to create working circuits.

For example, students create circuits that make physical quantities audible. Students are encouraged to realize their own circuit ideas.

Projects & Seminars: Assembling and Controlling a Tuning-Fork AFM

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

Invented in the 1980s in Zurich and awarded with the Kavli prize in 2016, the atomic force microscope (AFM) has enabled us to visualize surfaces at the single atom level, and to measure single molecule and cell-cell interactions, deepening our understanding of material science and biology. This is achieved by controlling micromechanical piezo actuators with nanometer precision and processing noisy signals in order to achieve meaningful data.

In order to introduce you to the capabilities of modern AFMs in biomedical sensing, you will build your own setups in groups of two. You will be introduced to an AFM’s functionality, control, and signal read-out using LabView. A signal of an oscillating tuning-fork will be used as feedback for the self-built AFM. In order to better understand the working principle of a tuning fork, you will also build your own frequency sweeper and analyze it with self-built low-pass filters.

After you have implemented your own setup, you will have the chance to characterize different biomedical samples on state-of-the-art setups. This data will then be analyzed using Python. The focus of this P&S seminar is to enable you to transfer your theoretical knowledge into practice and at the same time get to know how electrical engineering can be used in biomedical research.

The course requires active participation during the practical sessions, a 10-15 min presentation and a short written report on the acquired results. The course will be given in English.

Dates:
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
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</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
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<td></td>
<td>Negotiation</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
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<table>
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<tr>
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<th>Credits</th>
<th>Type</th>
<th>Instructor</th>
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<tr>
<td></td>
<td>Aspects of Renewable Energy Supply</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td></td>
<td>Only for Electrical Engineering and Information Technology BSc.</td>
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<tr>
<td></td>
<td>The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.</td>
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<tr>
<td>Abstract</td>
<td>The category of &quot;Laboratory Courses, Projects, Seminars&quot; includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>More and more sustainable and renewable energy technologies are used for electricity generation to cope with climate change. These distributed resources transform the electric power grid and impose major challenges.</td>
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<td></td>
<td>In this seminar, students have the opportunity to glance at cutting-edge research in the field of power systems. Possible research questions might be:</td>
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<tr>
<td></td>
<td>- How to integrate distributed energy generation like PV plants and wind turbines into the electricity grid?</td>
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<td></td>
<td>- What challenges does the increasing share of electric vehicles and batteries impose on the power grid?</td>
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<td></td>
<td>- How to cope with the uncertain generation capacity of renewables and how to forecast it?</td>
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<td></td>
<td>- How does the electricity market work and how do the new sources of flexibility transform it?</td>
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<td></td>
<td>Students will prepare a presentation and a report on their individual research question, which is based on an assigned paper. The main objectives are to practice literature review, scientific writing and presenting. Students will learn to independently understand specific research results – a crucial skill for academic research including summer and master projects.</td>
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<tr>
<td></td>
<td>The language of instruction is English. Registrations for the seminar are binding.</td>
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</tbody>
</table>

|             | Only for Electrical Engineering and Information Technology BSc. |         |      |            |
|             | The course unit can only be taken once. Repeated enrollment in a later semester is not creditable. |         |      |            |
| Abstract    | The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work. |         |      |            |
| Objective   | Python is an interpreted high-level programming language which is becoming increasingly popular in the academic scientific community as well as in industry. The course will introduce the basics of the python programming language, and will cover some of the most useful Python modules, such as numpy, scipy and matplotlib. The classes will further cover simple GUIs, data analysis and linking with shared libraries or C code. They will further familiarize with the GIT version control system, with the linux shell and with the most common software licenses. Students are not required to have previous Python programming experience. |         |      |            |

| 227-0085-16L| Projects & Seminars: Machine Learning for Brain-Computer Interfaces | 3 | W | L. Benini |
|             | Only for Electrical Engineering and Information Technology BSc. |         |      |            |
|             | The course unit can only be taken once. Repeated enrollment in a later semester is not creditable. |         |      |            |
| Abstract    | The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work. |         |      |            |
| Objective   | A brain-computer interface (BCI) provides a communication and control channel based on the recognition of subject’s intention from spatiotemporal activity of the brain. A typical method to acquire neural activity signals is electroencephalography (EEG), which is often used in BCI. In order to make these data usable and get useful information out of them, signal processing techniques play a crucial role. Moreover, feature extraction and machine learning methods are applied to obtain a highly accurate BCI. |         |      |            |
|             | The aim of the Project and Seminars course is to give insights of signal processing and machine learning applied to brain-computer interfaces to undergraduate students, by having hands-on experience in brain signal acquisition, data processing, feature extraction, and machine learning. |         |      |            |
Projects & Seminars: Building a Wireless Infrared 2P
M. Lerjen

Abstract
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
This P&S is about the design and operation of an optical infrared audio transmission system. For this purpose, we familiarize ourselves with important laboratory and measurement equipment (oscilloscope, spectrum analyzer) and measurement methods (record frequency response, S/N ratio, nonlinear interference). The influence of modulation to suppress interference will be investigated in experiments.

Each student builds an infrared transmitter and receiver. During assembly, we gain hands-on experience with soldering conventional and SMD components. The finished circuits are tested and tuned and can be taken home afterwards.

Projects & Seminars: Bits on Air 3P
W 2 credits 2P M. Lerjen

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
Digital communication is a part of our everyday lives, whether we are sending e-mails, watching TV, listening to the radio, or using a cell phone. In this P&S, we will familiarize ourselves with the basics of digital communication.

On conventional PCs, the students will implement their own software modems for data transmission. These modems, just like the digital communication systems used in real life, consist of a modulator, a demodulator and an algorithm to synchronize the carrier of the incoming message. Once implemented, these modems can be used to acoustically transmit any data (such as small text files) between PCs.

We use MATLAB but previous knowledge thereof is not assumed. Rather, the goal of the project is to practice programming with MATLAB in addition to learning basics of digital communication.

Projects & Seminars: Software Defined Radio 3P
W 3 credits 3P M. Lerjen

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
Wireless transmission of information is ubiquitous today. Depending on application and frequency range, different types of modulation are used, with digital methods having largely replaced the old analog methods. Software Defined Radio (SDR) tools make it possible to dive into this world and “surf the waves” with relatively little effort. More powerful computers allow for increasingly complex signal processing in transmitters and receivers. At the same time, the signal processing algorithms can be adapted and changed very quickly and flexibly.

In this P&S we will take a closer look at how SDR works. In the first part we will work on the basics of frequencies, spectra, modulation types, and signal processing.

In the second part we will work in groups on different projects with SDR tools. Students can also bring their own ideas. At the end, the projects will be presented in the class.

Projects & Seminars: Quad-Rotors: Control and Estimation 2P
W 2 credits 2P J. Lygeros

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
The objective of this P&S is to make a real-world quad-rotor fly autonomously by applying the control and estimation theory taught in class.

In the first half of the P&S, we will introduce the physical model for a quad-rotor and use this to apply the control and estimation techniques that are taught in the 5th semester in the Control System 1 class. The students will then create their own control function for a quad-rotor and test these in simulation. The second half of the course will involve the students implementing the control and estimation algorithms they design in the real-world on our fleet of nano-quad-rotors. Once stable flight is achieved, the students will have the freedom to perform tasks with the quad-rotor. By implementing the control and estimation algorithms on a real-quadcopter, the students will gain experience with how decisions in the modelling and design stage affect real-world performance.

Important Information:
Students must be in the 6th semester.
The first class will be Monday, September 21 for all students.
Classes will then occur every second week. The students will be split into two groups and the classes for each group will occur on alternating weeks.
It is preferable to be taking the Control Systems 1 (CS1) course but not mandatory. Those students who are not taking CS1 will need to complete some extra reading to understand some aspects of this P&S.
Due to COVID-19, the course will be offered in an online setting with classes being held over Zoom. The students will be able to take a real-world quad-rotor to their homes in order to implement the control and estimation algorithms taught in the course.
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Vision and Control in RoboCup is jointly offered by Prof. John Lygeros (IFA), Prof. Luc Van Gool (CVL) and Prof. Fisher Yu (CVL).

Projects & Seminars: Vision and Control in RoboCup

227-0085-24L

Projects & Seminars: Vision and Control in RoboCup in English

W 3 credits 1P

J. Lygeros, L. Van Gool, F. Yu

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The course is taught in English and open to 5th or higher semester students. A basic knowledge of programming in Python and MATLAB is required.

Projects & Seminars: Biosignal Acquisition and Processing for IoT Wearable Devices

227-0085-25L

Projects & Seminars: Biosignal Acquisition and Processing for IoT Wearable Devices in English

W 3 credits 3P

M. Weiger Senften

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The phenomenon of nuclear magnetic resonance (NMR) and its application for spectroscopy and imaging are introduced. The course starts with a general introduction to NMR, followed by measurements on a clinical MRI scanner. The NMR experiments will be developed and programmed by the students. Starting from a simple spectroscopic experiment, the basics of imaging will be acquired step-by-step. Finally, sectional images of test objects will be obtained.

Projects & Seminars: Magnetic Resonance: From Data to Image

227-0085-26L

Projects & Seminars: Magnetic Resonance: From Data to Image in English

W 1 credit 1P

L. Van Gool

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Biosignal acquisition and processing – Wearable sensor node design and analysis for bio-impedance sensor using an Arm Cortex-M (Nordic nrf52838) Microcontroller

Wearable smart sensor electronics has the potential to revolutionize the medical field. Various body conformal flexible sensors have been used to monitor motion and physiological electrical signals such as electrocardiography (ECG), electroencephalography (EEG) and body composition analysis via body bio-impedance measurements. Smart sensor nodes not only provide accurate and continuous data in time but also automate the process of maintaining medical records, thereby lowering the workload of the health worker or clinician. This course offers an avenue for the students to understand the interdisciplinary principles that make it possible to interpret human physiology by utilizing discreet electronic components. Most importantly, participants will get a chance to do hands-on system design specific to electronically tracking a particular physiological phenomenon. In particular, the focus will be laid on programming of micro controllers, interfacing with sensors, acquisition of data and utilizing discreet analog elements for bio-signal processing. The programming will be performed in C.

Projects & Seminars: Android Application Development (AAD)

227-0085-27L

Projects & Seminars: Android Application Development (AAD) in English

W 4 credits 3P

J. Lygeros

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Projects & Seminars: Android Application Development (AAD)
Although the App-Industry is dominated by the giant Apps right now, it is still crucial that one knows how those Apps function and how those Apps are communicating with their hardware. This course offers the opportunity for the participants to understand the development of application using Android Studio. Most importantly, participants will get a chance to Android Studio and software design specific to Android smartphone and the data acquisition from sensors, GPS, google maps and other internal devices. The main goal of the course if providing the students with the basic principle and software programming for build up every android application. The course include 4-5 weeks project were the students alone or in group will build up a working demo of a target application. The course will conclude with the presentation of the students work. Previous experience in C/Java or other languages is preferable but not mandatory. The students will program their own Android Smartphone.

The course will be taught in English by the new Project-based learning centre.

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<td>227-0085-31L</td>
<td>Projects &amp; Seminars: Vision Goes Vegas</td>
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Objective

Computer Vision beschäftigt sich unter anderem damit, Maschinen zu befähigen ihre Umwelt zu sehen und das wahrgenommene Bild zu verstehen. In unserem Projekt soll ein System entwickelt werden, das Spielkarten erkennen kann und, einer guten Strategie folgend, erfolgreich Black-Jack spielen kann. Die Teilnehmer des Projektes werden kleine Teams bilden und gemeinsam mit einem Assistenten die Aufgabe erarbeiten und eine Implementierung erstellen. Am Ende des Semesters sollen die Programme im öffentlichen Wettstreit gegeneinander antreten!


Als Voraussetzungen sollte Interesse an Computer Vision mitgebracht werden und die Bereitschaft, sich in einem Team von Mitstudierenden einzubringen. Kenntnisse in C++ sind notwendig.

Der Kurs wird von Prof. Fisher Yu mitbegutachtet.

Dieses P&S wird in englischer Sprache durchgeführt.

227-0085-32L
Projects & Seminars: Magnetic Fields in Our Daily Life
Only for Electrical Engineering and Information Technology BSc.

Objective

Magnetic fields can be found everywhere but are rarely directly perceptible. This also leads to sometimes irrational fears, such as of electrosmog. The power supply with direct current, 16.67 Hz and 50 Hz alternating current is indispensable today. Wherever electricity flows, magnetic fields are generated. That is why magnetic fields are omnipresent. But where do particularly high fields occur? How high can these fields be before they cause damage to health? Many studies have already dealt with this question and country-specific guidelines have been defined on this basis. But are these actually adhered to? Where are the legal limits exceeded? What are the consequences? The P&S will deal with this topic and an invited guest will speak.

The participants of the P&S will pursue small research projects of their own. To do this, they will be equipped with mobile measuring devices that can be connected to a smartphone to search for and characterise various magnetic field sources. How strong are the magnetic fields in our environment really? Can they pose a danger? How can they be shielded? These questions will be systematically investigated.

At the end of the P&S, the individual groups present the findings.

227-0085-33L
Projects & Seminars: Accelerating Genome Analysis
with FPGAs, GPUs, and New Execution Paradigms
Only for Electrical Engineering and Information Technology BSc.

Objective

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
Objective

A genome encodes a set of instructions for performing some functions within our cells. Analyzing our genomes helps, for example, to determine differences in these instructions (known as genetic variations) from human to human that may cause diseases or different traits. One benefit of knowing the genetic variations is better understanding and diagnosis of diseases and the development of efficient drugs.

Computers are widely used to perform genome analysis using dedicated algorithms and data structures. However, timely analysis of genomic data remains a daunting challenge, due to the complex algorithms and large datasets used for the analysis. Increasing the number of processing cores used for genome analysis decreases the overall analysis time, but significantly escalates the cost of building, maintaining, and cooling such a computing cluster, as well as the power/energy consumed by the cluster. This is a critical shortcoming with respect to both energy production and environmental friendliness. Cloud computing platform can be used as an alternative to distribute the workload, but transferring the data between the clinic and the cloud poses new privacy and legal concerns.

In this course, we will cover the basics of genome analysis to understand the computational steps of the entire pipeline and find the computational bottlenecks. Students will learn about the existing efforts for accelerating one or more of these steps and will have the chance to carry out a hands-on project to improve these efforts.

Prerequisites of the course:
- No prior knowledge in bioinformatics or genome analysis is required.
- Digital Design and Computer Architecture (or equivalent course)
- A good knowledge in C programming language is required.
- Experience in at least one of the following is highly desirable:
  - FPGA implementation and GPU programming.
  - Interest in making things efficient and solving problems

The course is conducted in English.

Course website: https://safari.ethz.ch/projects_and_seminars/ramulator/doku.php?id=ramulator

Learning Materials

3. An example of how to accelerate genomic sequence matching by two orders of magnitude with the help of FPGAs or GPUs: https://arxiv.org/abs/1910.09029
5. An example of using a different computing paradigm for accelerating read mapping step and improving its energy consumption: https://arxiv.org/pdf/1708.04329

== Course Information ==

Project 1: RAMulator

Projects & Seminars: Exploration of Emerging Memory Systems
Only for Electrical Engineering and Information Technology BSc.

Abstract

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Objective

In this P&S, you will design new memory and memory controller mechanisms for improving overall system performance, energy consumption, reliability, security, scalability and cost. You will extend Ramulator with these new designs and evaluate their performance, energy consumption, and reliability using modern applications.

This will be the right P&S for you if you would like to learn about the state-of-the-art and future memory and memory controller designs and their interaction with modern applications. This P&S will also enable you to hands-on simulate and understand the memory system behavior of modern workloads such as machine learning, graph analytics, genome analysis.

Content

DRAM is predominantly used to build the main memory systems of modern computing devices. Emerging memory technologies (RRAM, PCM, STT-MRAM, FeRAM) provide an exciting opportunity to replace or complement DRAM. Simulation-based experimental studies are key for understanding the complex interactions between DRAM, emerging memory technologies, and modern applications. Ramulator is an extensible main memory simulator providing cycle-accurate performance models for a variety of commercial DRAM standards (e.g., DDR3/4, LPDDR3/4, GDDR5, HBM), emerging memory technologies, and academic proposals. Ramulator has a modular design that enables easy integration of additional standards, technologies and mechanisms. Ramulator is written in C++11 and can be easily integrated to full-system simulators such as gem5.

Course website: https://safari.ethz.ch/projects_and_seminars/ramulator/doku.php?id=ramulator

Lecture notes

See https://safari.ethz.ch/projects_and_seminars/doku.php?id=ramulator

Learning Materials

3. An example of how to accelerate genomic sequence matching by two orders of magnitude with the help of FPGAs or GPUs: https://arxiv.org/abs/1910.09029
5. An example of using a different computing paradigm for accelerating read mapping step and improving its energy consumption: https://arxiv.org/pdf/1708.04329

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Projects & Seminars: FPGA-based Exploration of DRAM and RowHammer
Only for Electrical Engineering and Information Technology BSc.

Abstract

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Objective

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
In this P&S, you will have the chance to learn how DRAM is organized and operates in a low-level and gain practical experience in using SoftMC while developing SoftMC programs for new DRAM characterization studies related to performance, reliability, and security. You may also improve the SoftMC infrastructure itself to enable new studies. And, who knows, you might discover new security vulnerabilities like RowHammer.

This will be the right P&S for you if you are interested in DRAM technology and would like to learn more about it as well as FPGA technology and how it can be used for practical purposes such as understanding and mitigating RowHammer attacks, generating true random numbers, reducing memory latency, fingerprinting and identifying devices, and improving reliability.

Course website: https://safari.ethz.ch/projects_and_seminars/doku.php?id=softmc

Objective

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Abstract

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Objective

Genome analysis is the foundation of many scientific and medical discoveries, and serves as a key enabler of personalized medicine. This analysis is currently limited by the inability of existing technologies to read an organism’s complete genome. Instead, a dedicated machine (called sequencer) extracts a large number of shorter random fragments of an organism’s DNA sequence, known as reads. Small, handheld sequencers such as ONT MinION and Flongle make it possible to sequence bacterial and viral genomes in the field, thus facilitating disease outbreak analyses such as COVID-19, Ebola, and Zika. However, large, capable computers are still needed to perform genome assembly, which tries to reassemble read fragments back into an entire genome sequence. This limits the benefits of mobile sequencing and may pose problems in rapid diagnosis of infectious diseases, tracking outbreaks, and near-patient testing. The problem is exacerbated in developing countries and during crises where access to the internet network, cloud services, or data centers is even more limited.

In this course, we will cover the basics of genome analysis to understand the speed-accuracy tradeoff in using computationally-lightweight heuristics versus accurate computationally-expensive algorithms. Such heuristic algorithms typically operate on a smaller dataset that can fit in the memory of today’s mobile device. Students will experimentally evaluate different heuristic algorithms and observe their effect on the end results. This evaluation will give the students the chance to carry out a hands-on project to implement one or more of these heuristic algorithms in their smartphones and help the society by enabling on-site analysis of genomic data.

Content

- Familiarity with FPGA programming
- Interest in low-level hacking and memory
- Interest in discovering why things do or do not work and solving problems

Learning Materials

3. An example of how to accelerate genomic sequence matching by two orders of magnitude: https://arxiv.org/abs/1912.08735
5. An example of using a different computing paradigm for accelerating genomic sequence matching by two orders of magnitude: https://arxiv.org/abs/1604.01789
6. Two examples on using software/hardware co-design to accelerate genomic sequence matching by two orders of magnitude: https://arxiv.org/abs/1809.07858
7. An example of using a different computing paradigm for accelerating read mapping step by an order of magnitude and without using hardware acceleration: https://arxiv.org/pdf/1912.08735
8. An example of a purely software method for fast genome sequence analysis: http://www.biomedcentral.com/content/pdf/1471-2164-14-S1-S13.pdf

Prerequisites of the course:

- Digital Design and Computer Architecture (or equivalent course)
- Familiarity with FPGA programming
- Interest in low-level hacking and memory
- Interest in discovering why things do or do not work and solving problems

The course is conducted in English.

Lecture notes

See https://safari.ethz.ch/projects_and_seminars/doku.php?id=softmc for past examples.

Prerequisites / notice

The course is only for Electrical Engineering and Information Technology BSc.

Course website: https://safari.ethz.ch/projects_and_seminars/doku.php?id=softmc

Only for Electrical Engineering and Information Technology BSc.

The course can only be taken once. Repeated enrollment in a later semester is not creditable.

Objective

Fundamentally Improving Performance and Energy

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Abstract

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Objective

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Learning Materials

3. An example of how to accelerate genomic sequence matching by two orders of magnitude with the help of FPGAs or GPUs: https://arxiv.org/abs/1910.09020
5. An example of using a different computing paradigm for accelerating genomic sequence matching by two orders of magnitude: https://arxiv.org/abs/1604.01789
6. Two examples on using software/hardware co-design to accelerate genomic sequence matching by two orders of magnitude: https://arxiv.org/abs/1809.07858
7. An example of a purely software method for fast genome sequence analysis: http://www.biomedcentral.com/content/pdf/1471-2164-14-S1-S13.pdf

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.
Projects & Seminars: Controlling Biological Neuronal Networks Using Machine Learning

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Data movement between the memory units and the compute units of current computing systems is a major performance and energy bottleneck. From large-scale servers to mobile devices, data movement costs dominate computation costs in terms of both performance and energy consumption. For example, data movement between the main memory and the processing cores accounts for 62% of the total system energy in consumer applications. As a result, the data movement bottleneck is a huge burden that greatly limits the energy efficiency and performance of modern computing systems. This phenomenon is an undesired effect of the dichotomy between memory and the processor, which leads to the data movement bottleneck.

Many modern and important workloads such as machine learning, computational biology, graph processing, databases, video analytics, and real-time data analytics suffer greatly from the data movement bottleneck. These workloads are exemplified by irregular memory accesses, relatively low data reuse, low cache line utilization, low arithmetic intensity (i.e., ratio of operations per accessed byte), and large datasets that greatly exceed the main memory size. The computation in these workloads cannot usually compensate for the data movement costs. In order to alleviate this data movement bottleneck, we need a paradigm shift from the traditional processor-centric design, where all computation takes place in the compute units, to a more data-centric design where processing elements are placed closer to or inside where the data resides. This paradigm of computing is known as Processing-in-Memory (PIM).

This is your perfect P&S if you want to become familiar with the main PIM technologies, which represent “the next big thing” in Computer Architecture. You will work hands-on with the first real-world PIM architecture, will explore different PIM architecture designs for important workloads, and will develop tools to enable research of future PIM systems. Projects in this course span software and hardware as well as the software/hardware interface. You can potentially work on developing and optimizing new workloads for the first real-world PIM hardware or explore new PIM designs in simulators, or do something else that can forward our understanding of the PIM paradigm.

Prerequisites of the course:
- Digital Design and Computer Architecture (or equivalent course).
- Familiarity with C/C++ programming.
- Interest in future computer architectures and computing paradigms.
- Interest in discovering why things do or do not work and solving problems
- Interest in making systems efficient and usable

The course is conducted in English. The course has two main parts:
1. Weekly lectures on processing-in-memory.
2. Hands-on project: Each student develops his/her own project.

227-0085-38L Projects & Seminars: Controlling Biological Neuronal Networks Using Machine Learning* W 3 credits 2P J. Vörös

Does not take place this semester. Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The way memory and learning is achieved in the brain is an unsolved problem. Due to its relative simplicity, in-vitro neuroscience can help us discover the fundamentals of information processing in the brain. For this we can simulate a small number of biological neurons on top of an array of microelectrodes. Such an approach allows us to simulate the electrical activity of the neurons when they get stimulated.

Following this approach, we can investigate biological neural networks, that have about 5-50 neurons and a controlled network architecture. Still, their behavior remains highly unpredictable. Therefore, it is not yet clear how such networks need to be stimulated electrically in order to control their behavior. However, we can use machine learning to find a mapping between a stimulus and a desired response. More specifically, we can use reinforcement learning, since finding the right stimulation pattern is an instance of the so-called multi-armed bandit problem.

This P&S consists of two parts. In the first part we will introduce you to the way neurons can be simulated. You will learn how neurons work and how they communicate. The second part will be about machine learning. We will discuss the basics of both artificial neural networks (ANN) and reinforcement learning. As homework exercises you will implement a reward function for a provided reinforcement learner, which will control your biological networks. In addition you will implement an ANN, that replaces unsatisfactorily performing stimulation patterns with new patterns, that this network evaluates to perform better.

If the current situation will allow, the developed ANNs will be tested on real neurons in our laboratory.

This P&S will be given in English. In total, the P&S takes 8 afternoons and about 50 hours of homework (ANN implementation).


Does not take place this semester. Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
This beginner course to programming with Python - with a focus on applications in science and technology - is an ideal starting point for later courses. We will start with an introduction to the dev environment and tools for effective development to get you started. Then we will learn the basics of Python with exercises, and discover popular modules for data processing and visualisation that will be useful for your later studies and career. We conclude with an introduction to popular machine learning techniques and some time for you to implement your own small free-style projects.

By the end of the semester, you will
- be familiar with your PC's command-line interface and know how to use available dev environments effectively.
- have learned the basics of Python and be able to write basic programs that do what you want (most of the time) with the help of modules.
- be able to process, visualize and analyze numerical data, e.g. lab measurements, images, etc.
- have first experience with machine learning techniques
- maintain your first git repository and know how to collaborate with others on coding projects.

Language: English / German (if necessary)

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227-0085-44L Projects & Seminars: Understanding and Designing Modern SSDs (Solid-State Drives) - Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.
Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

NAND flash memory is the de facto standard in architecting a storage device in modern computing systems. As modern computing systems process a large amount of data at an unprecedented scale, a storage device needs to meet high requirements on storage capacity and I/O performance. A NAND flash-based SSD can provide an order(s) of magnitude higher I/O performance compared to traditional hard-disk drives (HDDs), with a much lower cost-per-bit value over any other SSDs based on emerging non-volatile memory (NVM) technologies.

NAND flash memory has several unique characteristics, such as the erase-before-write property (i.e., a flash cell needs to be first erased before programming it), limited lifetime (i.e., a cell can reliably store data for a certain number of program/erase cycles), and large operation units (e.g., a NAND flash chip reads/writes data in a page (e.g., 16 KiB) granularity). To achieve high performance and large capacity of the storage system while hiding the unique characteristics of NAND flash memory, it is critical to design efficient SSD firmware, commonly called Flash-Translation Layer (FTL). An FTL is responsible for many critical management tasks, such as address translation, garbage collection, wear-leveling, and I/O scheduling, that significantly affect the performance, reliability, and lifetime of the SSD.

In this P&S, we will cover how a modern NAND flash-based SSD is organized and operates, from the basics of underlying NAND flash devices and various SSD-management tasks at the FTL-level. You will build a practical SSD simulator by refactoring MoSim, a state-of-the-art simulator for high-end SSDs, to support advanced features of modern NAND flash chips and essential SSD-management tasks. This will allow you to have the chance to obtain a comprehensive background of modern storage systems and research experience on system optimization with rigorous evaluation.

Prerequisites of the course:

- No prior knowledge in NAND flash-based storage systems is required.
- Digital Design and Computer Architecture (or equivalent course)
- Good knowledge in C/C++ programming language is required.
- Interest in system optimizations

The course is conducted in English.

227-0085-45L Projects & Seminars: Robotic Maze Solving with a TI-RSLK Robot (RMaze)  W 3 credits 3P

Does not take place this semester.

Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Microcontroller programming (C) – Peripherals Interfacing using a MSP433 MCU – Control of a Robot in a maze

The course will focus on teaching how to build and program a Texas Instrument robotic system learning kit (TI-RSLK). It is a robot kit, which includes a 2 wheeled robot, a line sensor to determine lines on the floor as well as sensors to recognize walls. The robot is driven by a MSP432 state of the art ARM Cortex M4 processor.

This course will give the students the opportunity to learn how to program the microcontroller of this robot to navigate in a small maze. For this, the students will learn how to control the motors and, consequently the movement of the robot with the peripherals of the microcontroller. Next to the movement, also the control and readout of the attached sensors will be part of the P&S course.

Once the students are able to read sensor values and control the motors of the robot, this course will conclude with a 4-week project. Within this project the students will design their own algorithm, such that the robot can navigate autonomously within a maze. A small competition at the end of the P&S will find the fastest robot of the group.

This course will be taught in English by the new D-ITET center for Project-based learning, the programming toolchain will be installed on the student’s own laptop. Experience with microcontroller programming (C) is an advantage, however not required. A short introduction will be given during the course.

This course will be taught in English or in German if necessary.

227-0085-46L Projects & Seminars: Embedded Systems With Drones  W 4 credits 4P

Only for Electrical Engineering and Information Technology BSc.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective


Drones can be fun to use but understanding the hardware and software and building and programming them to be intelligent and autonomous is even better. This course gives the basis of the embedded systems having the drones as the primary target. The course will introduce embedded systems and, in particular, the microcontroller ARM Cortex-M, focusing on all the crucial blocks such as Interrupts, GPIO, ADC's, Timers, and Serial communication protocols. Apart from the core topics, real-time and power-efficient algorithms for attitude and motor control are also discussed, making the drone efficient. Finally, exciting drone exercises are supported in the course to experiment with the development kit. The course will end with a 4-5 weeks project where the students will make the drone fly with some specific goal. It is not required any previous knowledge except C language.

The course will be taught in English and organized by the new Project-Based Learning center.
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Smartphones have several sensors that can acquire much useful information, for instance where we are, what we are doing, with whom we are together, what is our constitution, what are our needs. Based on this information our 'smartphone' offers us the appropriate computational power to process them in loco without sending the sensor data to the cloud. This course focus on giving the bases of machine learning and embedded systems. The student will learn the tools to implement a machine learning algorithm, such as Tensor Flow and others in their android phones to have an advanced smartphone. The course will end with 4 weeks project where the students can target a specific application scenario. It is not required any previous experience in machine learning. Phyton is a plus but the basis of phyton will be given in the course to be able to complete the project.

The course will be taught in English and organized by the new Project-based Learning center.

Abstract

Objective

227-0085-48L  Projects & Seminars: Introduction to Program Nao Robots for Robocup Competition
Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

Objective

227-0085-49L  Projects & Seminars: Smart Patch Projects
Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

Objective

The projects will be done under the Smart Patches: a flagship project for D-ITET students. (pbl.ee.ethz.ch)

227-0085-51L  Projects & Seminars: Programming Heterogeneous Computing Systems with GPUs
Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

Objective
Objective

The increasing difficulty of scaling the performance and efficiency of CPUs every year has created the need for turning computers into heterogeneous systems, i.e., systems composed of multiple types of processors that can suit better different types of workloads or parts of them. More than a decade ago, Graphics Processing Units (GPUs) became general-purpose parallel processors, in order to make their outstanding processing capabilities available to many workloads beyond graphics. GPUs have been critical to the recent rise of Machine Learning and Artificial Intelligence, which took unrealistic training times before the use of GPUs. Field-Programmable Gate Arrays (FPGAs) are another example computing device that can deliver impressive benefits in terms of performance and energy efficiency. More specific examples are (1) a plethora of specialized accelerators (e.g., Tensor Processing Units for neural networks), and (2) near-data processing architectures (i.e., placing compute capabilities near or inside memory/storage).

Despite the great advances in the adoption of heterogeneous systems in recent years, there are still many challenges to tackle, for example:
- Heterogeneous implementations (using GPUs, FPGAs, TPUs) of modern applications from important fields such as bioinformatics, machine learning, graph processing, medical imaging, personalized medicine, robotics, virtual reality, etc.
- Scheduling techniques for heterogeneous systems with different general-purpose processors and accelerators, e.g., kernel offloading, memory scheduling, etc.
- Workload characterization and programming tools that enable easier and more efficient use of heterogeneous systems.

If you are enthusiastic about working hands-on with different software, hardware, and architecture projects for heterogeneous systems, this is your P&S. You will have the opportunity to program heterogeneous systems with different types of devices (CPUs, GPUs, FPGAs, TPUs), propose algorithmic changes to important applications to better leverage the compute power of heterogeneous systems, understand different workloads and identify the most suitable device for their execution, design optimized scheduling techniques, etc. In general, the goal will be to reach the highest performance reported for a given important application.

Prerequisites of the course:
- Digital Design and Computer Architecture (or equivalent course).
- Familiarity with C/C++ programming and strong coding skills.
- Interest in future computer architectures and computing paradigms.
- Interest in discovering why things do or do not work and solving problems.
- Interest in making systems efficient and usable.

The course is conducted in English.

The course has two main parts:
1. Weekly lectures on GPU and heterogeneous programming.
2. Hands-on project: Each student develops his/her own project.

Content

Course website: https://safari.ethz.ch/projects_and_seminars/spring2022/doku.php?id=heterogeneous_systems

Lecture notes

See https://safari.ethz.ch/projects_and_seminars/spring2022/doku.php?id=heterogeneous_systems_for_past_examples.

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<tr>
<th>Code</th>
<th>Title</th>
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<td>Abstract</td>
<td>The category of &quot;Laboratory Courses, Projects, Seminars&quot; includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.</td>
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<td>Objective</td>
<td>Current MRI scans are limited by patient motion. In clinics, radiologists are often confronted with images with severe motion artefacts in their images. They either have to make a diagnosis although the image artefacts were they could miss crucial information, or they have to send the patient back into the scanner for reacquisition. Such reacquisition might inflict additional costs in the six-figure range per scanner per year. Further, in research, MRI images from ultra-high field systems are already limited by motion from the cardiobalistic and respiratory movement. Resulting in subpar performance if not addressed appropriately. The key to overcoming such motion artefacts is estimating the motion and correct for it. Preferably this is done prospective in real-time or otherwise afterwards retrospective in the image reconstruction. Such methods are instrumental in brain imaging since the brain's movement is well described by the rigid body behaviour of the skull. To do such motion correction, one needs a motion-sensing technology to measure the movement of the human skull with high precision, accuracy and temporal resolution. All this has to be done while being integrated into an MRI machine where powerful static magnetic fields are present, kW of pulsed RF power and MVA of changing magnetic field gradients are present. In this P&amp;S we explore different motion sensing technologies suitable for deployment in an MRI machine. Which you can expect is that we discuss the theory of multiple sensing technologies and then implement an optical, shortwave RF and NMR phase motion sensor. We will spend most of our time in the lab constructing such sensors and testing them on our robotic test bench. Finally, we would also experiment in our MRI facilities, where we would perform motion correction experiments.</td>
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<td>227-0085-54L</td>
<td>Projects &amp; Seminars: Optics and Spectroscopy Lab</td>
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<td>3 credits</td>
<td>4P, J. Leuthold</td>
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<td>Objective</td>
<td>The goal of this P&amp;S is to learn the basics of working with optics and how to assemble optical systems. It is intended to show the practical side to the many optics lectures that are offered at D-ITET. The course will give a very brief introduction on laser safety, basic building blocks for optics and information on how to handle such elements. The following classes allow the students to test very basics properties of lenses and lasers and how the corresponding optomechanics can be used to arrange a simple setup. After this, the different student groups rotate through four different experiments where they get the chance to build and align different optical setups and perform various measurements. No prior knowledge is required.</td>
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Projects & Seminars: Intelligent Architectures via Hardware/Software Cooperation

Only for Electrical Engineering and Information Technology BSc.

Objective

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Abstract

Modern general-purpose processors are agnostic to an application's high-level semantic information. Hence, they employ prediction-based techniques to enable computational and memory optimizations, such as prefetching, cache management policies, memory data placement, instruction scheduling, and many others. As such, the potential of such optimizations is limited due to the limited information the underlying hardware can discover on its own and such optimizations come with large area, power and complexity overheads required by the hardware for prediction purposes. Purely-hardware optimizations cannot achieve their performance potential and waste power, complexity and hardware area, since they are not aware of the application characteristics. On the other hand, purely-software optimizations are fundamentally tied up and limited by the underlying hardware.

A promising way to increase the performance of modern applications is to co-design software and hardware. Hence, lately both industry and academia are making serious attempts to improve performance, energy and security using hardware/software cooperative schemes such as application-specific hardware accelerators (e.g., Google’s Tensor Processing Unit) and application-specific extensions in general-purpose processors (e.g., Media Engine in Apple M1).

In this course, we will explore several different topics around hardware/software co-design such as: (i) new hardware/software interfaces (e.g., virtual memory, instruction set architecture) to enhance performance, energy and security, (ii) hardware/software co-design schemes to improve the performance of the memory subsystem in killer memory-intensive applications (e.g., sparse and irregular workloads), (iii) hardware/software cooperative machine-learning-based techniques for different microarchitectural components such as prefetchers, caches and branch predictors, which would continuously learn from the vast amount of memory accesses seen by a processor and adapt to the varying workload and system conditions.

If you are enthusiastic about working hands-on to design both software and hardware, this is your P&S. You will have the opportunity to study modern applications, propose software changes to better match the underlying hardware components, design new hardware components that better match the overlying software and come up with new machine-learning techniques to design efficient microarchitectural components. You will also learn how to program industry-supported microarchitectural simulators and study the performance of modern workloads after your hardware/software modifications.

Prerequisites of the course:
- Digital Design and Computer Architecture (or equivalent course).
- Familiarity with C/C++ programming and strong coding skills.
- Interest in future computer architectures and computing paradigms.
- Interest in discovering why things do or do not work and solving problems
- Interest in making systems efficient and usable

Preferable:
- Hands-on experience with Machine Learning frameworks (depends on the topic you choose)

The course is conducted in English.

Projects & Seminars: Wearable Ultrasound: Tools and Technologies

Only for Electrical Engineering and Information Technology BSc.

Objective

Ultrasonic is one of the most used medical imaging techniques and it enables many application, including the monitoring of musculoskeletal activity during movement, the imaging of carotid artery, and the control of prosthetic devices for human-machine interfaces. Recent developments showcased wearable ultrasound probes operating at minimal power consumption, enabling multi-day continuous monitoring of physiological parameters, and many companies and research centers are actively working on the development of the next generation of truly-wearable ultrasound for a number of monitoring and diagnostics applications.

The goal of this course is the development of the understanding of the main features required for successfully developing a wearable ultrasound probe. The students will learn about transducer control, signal processing for ultrasound, beamforming and generation of images, microcontroller-based wireless communication, and practical procedures for ultrasound experiments. The course will also include an introductory lecture on Python.

The course will be taught in English.

Projects & Seminars: Autonomous Cars and Robots

Only for Electrical Engineering and Information Technology BSc.

Objective

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Projects & Seminars: Wearable Ultrasound: Tools and Technologies

Only for Electrical Engineering and Information Technology BSc.

Objective

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Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
Autonomous mobile robotics is a promising field that spans from food delivery robots to the Perseverance Mars rover. In this P&S you will be introduced to the fundamental building blocks of robotics, by hands on experience in the context of the F1TENTH autonomous racing and the Robot Operating System (ROS).

Autonomous racing pushes the boundaries in algorithmic design and implementation in the fields of perception, planning and control. Thus it serves researchers as a limits test for autonomous driving and is an important building step in the field of general self driving and AI. F1TENTH is an open-source autonomous racing competition involving a racing car in the scale of 1:10.

This P&S allows you to apply hands-on robotics and is the right fit for you if you want to further delve into this fascinating field of embedded systems, perception, planning and control. Lastly, you will get experience in the widely used ROS framework.

Prerequisites / notice
- Can use the Linux-Terminal (e.g. navigating folder structure and ssh)
- Python (e.g. basic loops, OOP)
- Interest in autonomous driving
- 20GB of free space on your laptop

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Objective
The objective of this P&S is to expose students to both common and cutting-edge neural architectures and to build intuition about their inner working by the means of examples. Students learn about various network structures as building blocks and use them to solve worked examples and course challenges. After attending this course, students will be familiar with multi-layer perceptrons, convolutional neural networks, recurrent neural networks, transformer encoders, graph convolutional/isomorphism/attention networks, and autencoders.

Content
This P&S introduces deep learning through the PyTorch framework in a series of hands-on examples, exploring topics in computer vision, natural language processing, graph neural networks, and representation learning.

Lecture notes
Python Notebooks will be distributed to students before every session.

★★ Group Projects

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<th>Number</th>
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<td>Abstract</td>
<td>Students must work in groups in supervised projects for 150 to 180 hours minimum. The topics of the group work are open and can be technical of specific nature or more general in the context of engineering.</td>
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★★ Internship in Industry

The internship in industry can only be enrolled for during bachelor's studies according to the 2016 regulations. According to the 2018 regulations, an internship in industry can be taken at master's level.

Please note the conditions for internships in industry as set forward by the “Guidelines for the “Laboratory Courses - Projects - Seminars””, see https://ethz.ch/content/dam/ethz/special-interest/let/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_v5_final.pdf (German only).

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<td>227-0093-10L</td>
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<td>external organisers</td>
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<tr>
<td>Abstract</td>
<td>Only for students in the Bachelor's Programme Electrical Engineering and Information Technology, Regulations 2016. For students enrolled in the 2018 Programme Regulations, see “227-1550-10L Internship in Industry” at Master's level.</td>
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<tr>
<td>Objective</td>
<td>The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Please note the conditions for Internships in industry as set forward by the “Guidelines for the “Laboratory Courses - Projects - Seminars””, see <a href="https://ethz.ch/content/dam/ethz/special-interest/let/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_v5_final.pdf">https://ethz.ch/content/dam/ethz/special-interest/let/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_v5_final.pdf</a> (German only).</td>
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★★ Additional Subjects

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<tr>
<td>227-0651-00L</td>
<td>Applied Circuit and PCB-Design</td>
<td>W</td>
<td>2</td>
<td>4G</td>
<td>A. Blanco Fontao</td>
</tr>
<tr>
<td>Abstract</td>
<td>Participants learn how to design a predefined electronic circuit and how to lay out the pertaining circuit board. CAE and CAD activities for design and simulation are carried out with the aid of Altium Designer.</td>
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<td>Objective</td>
<td>The goal is to become acquainted with all those practical aspects of electronic circuit and PCB design by working through a modest but complete application example. This involves analysis of specifications, the evaluation of electronic parts, efficient testing and failure search, electromagnetic compatibility (EMC), the usage of industrial CAE/CAD tools for circuit simulation and PCB layout, generating production data for the board manufacturer, board mounting, testing and start up.</td>
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Content
- Development - from the idea to the final product
- Analysis of given circuit specifications
- Searching the Internet for electronics parts
- Choosing electronic parts: avoiding mistakes
- Setting up the Altium Designer environment
- Structure of component libraries
- Preparing schematic symbols for CAE
- Preparing footprints for CAD
- Linking component libraries and databases
- Introduction to Concord Pro and Supply Chain Management
- Structure of schematic diagrams and circuits
- Assigning schematic functions to physical parts
- Capturing a predefined circuit
- Hints for improved testing and failure analysis
- Checking schematic data
- Simulation of mixed-signal circuits using Spice
- Introduction to PCB manufacturing
- Turning circuit schematics into a workable layout using Altium Designer
- Component placement on the PCB
- Manual and automatic interconnect routing
- Design for EMC and High-Speed
- Preparation of production data for the board manufacturer
- Documentation for manufacturing and assembly
- PCB assembly (component mounting and soldering)
- Final circuit testing and start-up.

Literature
All necessary documents will be available as electronic documents (PDF).

Prerequisites / notice
- The course is recommended to all students who plan to design an electronic circuit or a PCB in an upcoming term project or as part of their master thesis. Attending this course during the term before will ensure they are optimally prepared and will allow them to fully focus on their project.

- The number of participants is limited.
- For their own students and staff, the Department of Information Technology and Electrical Engineering provides electronic components and consumables free of charge. All other participants have to bear a 200 CHF fee for those items.

Taught competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Cooperation and Teamwork assessed

Personal Competencies
- Creative Thinking assessed
- Self-direction and Self-management assessed

5th Semester: Third Year Core Courses
Can be freely combined, a list of recommendations is available under https://ee.ethz.ch/studies/bachelor/third-year/core-courses.html

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<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
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Abstract
The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective
The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content
1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum,
   - decimation and interpolation, digital filter design,
   - stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   - probability, random variables, discrete-time stochastic processes;
   - detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
   - Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes
Lecture Notes

227-0102-00L | Discrete Event Systems | W | 6 | 4G | L. Josipovic, L. Vanbever, R. Wattenhofer |

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.
Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes
Available

Literature
[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser.

227-0103-00L Control Systems

Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content

Prerequisites / notice
MATLAB is used for system analysis and simulation.

227-0113-00L Power Electronics

Abstract
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis, procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis, procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Prerequisites / notice
Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Lecture notes
Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/
Abstract
Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

Objective
Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

Content
Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Lecture notes
Lecture Slides

Literature

227-0124-00L	Embedded Systems	W	6 credits	4G	M. Magno, L. Thiele

Abstract
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

Objective
Understanding specific requirements and problems arising in embedded system applications.

Content
Using the formal models and methods in embedded system design in practical applications using the programming language C, the operating system FreeRTOS, a commercial embedded system platform and the associated design environment.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems FreeRTOS, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

Lecture notes
More information is available at https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html.

Literature


Prerequisites
Recommended background:
Undergraduate physics, mathematics, semiconductor devices

227-0145-00L	Solid State Electronics and Optics	W	6 credits	4G	N. Yazdani, V. Wood

Abstract
"Solid State Electronics" is an introductory condensed matter physics course covering crystal structure, electron models, classification of metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and optical properties of solids.

Objective
Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.

Content
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is shared resources, low-power and low-energy design, hardware architecture synthesis.

Lecture notes
The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html.

Literature


Prerequisites
Recommended background:
Undergraduate physics, mathematics, semiconductor devices

227-0166-00L	Analog Integrated Circuits	W	6 credits	2V+2U	T. Jang

Abstract
Analog integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Objective
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes
Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature

227-0311-00L	Qubits, Electrons, Photons	W	6 credits	3V+2U	T. Zambelli

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).
Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).

Content
- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature
- Supplementary material will be uploaded in Moodle.

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II".

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Taught competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: not assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: assessed
- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: assessed
  - Negotiation: not assessed
- Personal Competencies
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: assessed

227-0385-10L
Biomedical Imaging
W 6 credits 5G
S. Kozerke, K. P. Prüsmann

Abstract
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

Objective
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

Content
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 858 of 2345
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field

L1. Bioelectricity history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Bioassessment techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

### 5th Semester: Third Year Additional Foundation Courses

Students complete at least two of the Additional Foundation Courses available for selection. Recommendations are available under [https://ee.ethz.ch/studies/bachelor/third-year/additional-foundation-courses.html](https://ee.ethz.ch/studies/bachelor/third-year/additional-foundation-courses.html)

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<tr>
<td>227-0014-20L</td>
<td>Computational Thinking</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>R. Wattenhofer</td>
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#### Abstract
We will cover algorithmic principles, dynamic and linear programming, complexity, electronic circuits, P vs. NP, Turing machines, reductions, cryptography, zero-knowledge proofs, data organization, dictionaries, hashing, databases, SQL, machine learning, regression, clustering, deep neural networks. We will use Python as a programming language. There will be paper and programming exercises every week.

#### Objective
Computation is everywhere, but what is computation actually? In this lecture we will discuss the power and limitations of computation. Computational thinking is about understanding machine intelligence: What is computable, and how efficiently?

Understanding computation lies at the heart of many exciting scientific, social and even philosophical developments. Computational thinking is more than programming a computer, it means thinking in abstractions. Consequently, computational thinking has become a fundamental skill for everyone, not just computer scientists. For example, functions which can easily be computed but not inverted are at the heart of understanding data security and privacy. Machine learning on the other hand has given us fascinating new tools to teach machines how to estimate functions. Thanks to clever heuristics, machines now appear to be capable of solving complex cognitive tasks. To give just one more example: How can we design the best electronic circuit for a given problem? In this class, we study various problems together with the fundamental theory of computation.

The weekly lectures will be based on blackboard discussions and coding demos, supported by a script and coding examples. The course uses Python as a programming language. Python is popular and intuitive, a programming language that looks and feels a bit like human instructions. The lecture will feature weekly exercises, on paper and in Python.

| 227-0053-00L | High-Frequency Design Techniques | W | 4 credits | 2V+2U | C. Bolognesi |

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Abstract
Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible; higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective
Familiarize students with the essential tools and principles exploited in high-frequency design. Introduction to circuit simulation.

Content
Introduction to wireless, radio spectrum, review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, antenna basics.

Lecture notes
Lecture notes

Literature

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227-0122-00L
Introduction to Electric Power Transmission: System and Technology

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<td>227-0122-00L</td>
<td>Introduction to Electric Power Transmission: System and Technology</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>C. Franck, G. Hug</td>
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Abstract
Introduction to theory and technology of electric power transmission systems.

Objective
At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of transformers and lines, calculate stationary power flows and other basic parameters in simple power systems.

Content
Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems.

Lecture notes
Lecture script in English, exercises and sample solutions.

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Electives
This is only a small selection. Other courses from the ETH course catalogue may be chosen. Please consult the "Richtlinien zu Projekten, Praktika, Seminar" (German only), published on our website (http://www.ee.ethz.ch/pps-richtlinien).

Economics, Law and Management Electives
These subjects are particularly suitable for students planning to apply to the Master's Degree Program in Energy Science and Technology (MSc EST) or Management, Technology and Economics (MSc MTEC).

Number | Title | Type | ECTS | Hours | Lecturers |
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<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
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Abstract
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
(1) broaden understanding of management principles and frameworks
(2) advance insights into the sources of corporate and entrepreneurial success
(3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

Content
The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.
This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise. Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Students who are enrolled for "Discovering Management Exercises" exercises are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.


The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

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Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.


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The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate intellectual property rights. This knowledge is imparted based on current cases.

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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**851-0703-00L Introduction to Law**

*Students who have attended or will attend the lecture "Introduction to Law for Civil Engineering and Architecture" (851-0703-03L) or "Introduction to Law" (851-0708-00L), cannot register for this course unit.*

**Abstract**
This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

**Objective**
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

**Content**
Basic concepts of law, sources of law.
Private law: Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.
Insights into the law of the EU and into criminal law.

**Lecture notes**
Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

**Literature**
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

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**851-0735-10L Law for Entrepreneurs**

*Particularly suitable for students of D-ARCH, D-MAVT, D-MATL*

**Abstract**
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Objective**
The students shall obtain the following competencies:
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

**Lecture notes**
A comprehensive script will be made available online on the moodle platform.

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**851-0738-00L Intellectual Property: Introduction**

*Particularly suitable for students of D-CHAB, D-INFK, D-ITET, D-MAVT, D-MATL, D-MTEC*

**Abstract**
The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

**Objective**
The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

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**851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector**

*Particularly suitable for students of D-BAUG, D-BIOL, D-BSSE, D-CHAB, D-ITET, D-MAVT*

**Abstract**
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.
Objective
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

Prerequisites / notice
The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Taught competencies
Subject-specific Competencies
Concepts and Theories
Methods and Theories
Problem-solving

Method-specific Competencies
Critical Thinking
Personal Competencies
Self-awareness and Self-reflection

The lecture addresses students in the fields of engineering, science and other related technical fields.

Engineering Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning W</td>
<td>6</td>
<td>credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Students master the basic mathematical concepts and algorithms of estimation and machine learning.</td>
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<tr>
<td>Content</td>
<td>Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more</td>
<td></td>
<td></td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes will be handed out as the course progresses.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>solid basics in linear algebra and probability theory</td>
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<tr>
<td>227-0110-00L</td>
<td>Electromagnetic Waves: Materials, Effects, and Antennas W</td>
<td>6</td>
<td>credits</td>
<td>4G</td>
<td>U. Koch</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions. You know how waves interact with matter and about nonlinear and resonant effects. You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.</td>
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</tr>
</tbody>
</table>
| Content         | The lecture covers the following topics:  
| | - Generic time-harmonic electromagnetic fields  
| | - Fundamental solutions of the wave equation  
| | - Wave propagation in various types of materials  
| | - Interaction of waves with matter  
| | - Nonlinear effects  
| | - Resonant effects  
| | - Applications like scattering, waveguiding, radiation  
| | - Radio frequency and optical antennas |
| Lecture notes   | Lecture notes and slides will be handed out during the lectures. |
| Prerequisites / notice | |
| 227-0517-10L    | Fundamentals of Electric Machines W                 | 6    | credits | 4G    | D. Bortis          |
| Abstract        | This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed. |
| Objective       | The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts. |
| Content         | - Fundamentals in magnetic circuits and electromechanical energy conversion.  
| | - Force and torque calculation.  
| | - Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machines, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).  
| | - Complex space vector notation, rotating coordinate system (dq-transformation).  
| | - Loss components in electric machines, scaling laws of electromechanical actuators.  
| | - Mechanical and thermal modelling. |
| Lecture notes   | Lecture notes and associated exercises including correct answers |
| 227-0652-00L    | Maxwell, Einstein, and the GPS W                     | 6    | credits | 2V+2U | T. Zambelli        |

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In this seminar course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of

- Galileo-Newton, the Ether, Michelson-Morley's Experiment
- (Special Relativity) L. Susskind and A. Friedman, "Special Relativity and Classical Field Theory: The Theoretical Minimum", 2019, Hachette Book Group USA

Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

Maxwell's equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell's equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

Maxwell's equations are reinterpreted in the framework of Einstein's special relativity theory using the Lagrangian formalism in order to
discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS
atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

D-ITET is the depository of the Maxwell’s equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves.

Only one aspect is left over: the fact that they are not invariant with respect to the classical Galilean transformation… On the contrary, Maxwell’s equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell’s equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

- (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
- (Special Relativity) L. Susskind and A. Friedman, "Special Relativity and Classical Field Theory: The Theoretical Minimum", 2019, Hachette Book Group USA
- (Special Relativity) L. Susskind and A. Friedman, "Special Relativity and Classical Field Theory: The Theoretical Minimum", 2019, Hachette Book Group USA

Supplementary material will be uploaded in Moodle.

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+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA

NOTES: a few Wednesdays are lectures (NOT exercises!), details in Moodle!
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystems and devices by the combination of unit process steps (= process flow).

The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics will described too.

The lecture concludes with an excursion to a large manufacturing company. Here, students can see the application and realization of the manufacturing of electronic and electric devices.

- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

The course also covers support for data cubes (analytics).

- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice

Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice.

Literature

- Design of Digital Circuits.
- Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice.

Lecture notes

All the materials will be posted on the course website: https://safari.ethz.ch/architecture_seminar/

See https://safari.ethz.ch/architecture_seminar for past examples.

Content

- The lecture follows the value added process sequence of electric and electronic components. It contains: Development of electric and electronic circuits, design of electronic circuits on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electronic on a wafer as well as recycling.
- Knowledge about the value added process sequence for electronics manufacturing, planning of electric and electronic product as well as their production, planning of production lines, value added process sequence for photovoltaics.
- The lecture starts with a brief introduction of electronic components and the planning of integrated circuits. Next, an overview will be provided about electronic functional units assembled from these electronic components, on printed circuit boards as well as in hybrid technology. Value added process steps are shown as well as their quality check and their combination for planning a complete manufacturing line. The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics will described too.
- The lecture concludes with an excursion to a large manufacturing company. Here, students can see the application and realization of the manufacturing of electronic and electric devices.

Prerequisites / notice

Lecture notes are handed out during the individual lessons (CHF 20.-).

The lecture is partly given by experts from industry.

It is supplemented by an excursion to one of the industry partners.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td>assessed</td>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
<td>Customer Orientation</td>
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</table>

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Objective

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL
6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage
11. Data cubes
12. Analytics on top of a relational database

Taking a relational database to the next level

- Lecture material (slides).

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Literature

- Lecture material (slides).

Academic Press

376-0221-00L Basics of Air Transport (Aviation I) W 4 credits 3G P. Wild

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Abstract

In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation. The program is taught in English and we provide 11 different experts/lecturers.

Objective

The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport. Ideal foundation for Aviation II - Management of Air Transport.

Content

Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

Lecture notes

Preparation materials & slides are provided prior to each class

Literature

Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

Prerequisites / notice

The lecture is planned as class teaching.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: assessed
- Leadership and Responsibility: not assessed
- Sensitivity to Diversity: assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Bachelor's Project

The Bachelor's Thesis is the final part of the bachelor's program and should therefore only be taken in the semester in which the bachelor's diploma is acquired.

The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B) and
- subjects of the second year (examination blocks 1-3)

Number Title Type ECTS Hours Lecturers

227-0100-00L Bachelor's Thesis O 12 credits 26D Supervisors

Abstract

During the Bachelor's Thesis, students will gain initial experience in the independent solution of a technical-scientific problem by applying the acquired specialist and social skills.

A Bachelor's Thesis should take about half of a student's time during one semester, i.e., about 300-400 hours. The thesis includes an oral presentation and a written report, and it is graded.

Objective

see above
Prerequisites / notice

A 14 week long Bachelor's Thesis is the final part of the bachelor's program and shall therefore be taken during the semester in which the bachelor's diploma is acquired.

The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B)
- subjects of the second year (examination blocks 1-3)

Supervisor must be a professor at D-ITET or associated, see a link to the lists of those at https://ee.ethz.ch/studies/bachelor/third-year/bachelor-project.html

227-1101-00L How to Write Scientific Texts E- 0 credits U. Koch

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, "in this paper" paragraph, scientific part, summary, equations, figures)
* Topic 2: Structure of Scientific Presentations
* Topic 3: Citation Rules and Citation Software
* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html
ETH "Scientific Integrity", see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>Electrical Engineering and Information Technology Bachelor - Key for Type</th>
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</thead>
<tbody>
<tr>
<td>O</td>
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<td>W+</td>
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<td>Dr</td>
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<tr>
<th>Key for Hours</th>
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<td>V</td>
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<table>
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<tr>
<th>ECTS</th>
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</table>

Special students and auditors need special permission from the lecturers.
### Educational Science

#### General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
<tr>
<td></td>
<td>This lecture is only apt for students who intend to enrol in the programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about learning in childhood and adolescence.</td>
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<tr>
<td>Abstract</td>
<td>This course looks into scientific theories and also empirical studies on human learning and relates them to the school.</td>
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<tr>
<td>Objective</td>
<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
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<tr>
<td>Content</td>
<td>Thematische Schwerpunkte: Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<tr>
<td>Lecture notes</td>
<td>Folien werden zur Verfügung gestellt.</td>
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<tr>
<td>Prerequisites</td>
<td>This course is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
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#### Another course offering:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>U. Markwalder, S. Maurer, S. Peteranderl-Rüsshoff</td>
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<tr>
<td></td>
<td>Number of participants limited to 20.</td>
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<tr>
<td>Abstract</td>
<td>In this class, students will learn concepts and skills for coping with psychosocial demands of teaching</td>
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<tr>
<td>Objective</td>
<td>Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.</td>
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<td></td>
<td>(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).</td>
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<td>(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).</td>
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#### Another course offering:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects (EW2)</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td>Abstract</td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW1)&quot;.</td>
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<tr>
<td>Objective</td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<tr>
<td>Prerequisites</td>
<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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#### Another course offering:

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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0242-07L</td>
<td>Human Intelligence (EW2)</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
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<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td>Abstract</td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<tr>
<td>Objective</td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td></td>
<td>- Getting to know intelligence tests</td>
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<td></td>
<td>- Understanding findings relevant for education</td>
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#### Another course offering:

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td></td>
<td>Number of participants limited to 30.</td>
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<tr>
<td>Abstract</td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<tr>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 869 of 2345
Learning (EW 1)”.

Abstract

Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective

- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

851-0242-11L Gender Issues In Education and STEM ■

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract

In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the underrepresentation of girls and women in science, technology, engineering and mathematics (STEM); Common perspectives, controversies and empirical evidence will be discussed.

Objective

- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher's work.

Content

Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them. The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice

Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

851-0228-00L Formation of Knowledge in STEM Fields in Primary and Secondary School ■

Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in the course 851-0240-00L “Human Learning (EW 1)”.

Abstract

The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

Objective

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar participants are actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

Subject Didactics and Professional Training

Important: You can only enroll in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Number Title Type ECTS Hours Lecturers
227-0857-00L Subject Didactics I for D-MAVT and D-ITET ■ O 4 credits 3G O. Lohmeyer, R. Büchi

Abstract

Didactics I focuses on teaching techniques as building blocks of typical lessons. This is done on the basis of the findings of teaching and learning research and their implementation in practice. The aim is the planning and implementation of effective teaching sequences as well as their evaluation and reflection.

Objective

- The students can plan, conduct and critically reflect single lessons.
- They orient themselves towards the academic goals and take into account existing knowledge, the professional environment and the ambitions of the students.
- They can apply the basic teaching principles meaningfully in their subject and suitably structure the learning phases.
- They can reduce and present complex technical content such that it is in a form suitable for the students to learn.
- They have considered examples of the common conceptual errors encountered by students

Content

- Planning a teaching unit
- Opening a lecture
- Direct Instruction
- Blackboard writing and slide design
- Develop exercises
- Practicing teaching
- Excursion Fachhochschule

Lecture notes

Lecture materials are provided via Moodle.

Prerequisites / notice

Prerequisite: Educational science course already completed or at the same time.

227-0859-10L Teaching Internship Including Examination Lessons Electrical Engineering and Information Technology ■

The teaching internship can just be visited if all other courses of TC are completed.

Repetition of the teaching internship is excluded even if
the examination lessons are to be repeated.

Abstract
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are assessed as Examination Lessons.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Die Themen für die beiden Prüfungslektionen am Schluss des Praktikums erfahren die Studierenden in der Regel eine Woche vor dem Prüfungstermin. Sie erstellen eine Vorbereitung gemäß Anleitung und reichen sie bis am Vortag um 12 Uhr den beiden Prüfungsexperten (Fachdidaktiker/-in, Departementsvertreter/-in) ein. Die gehaltenen Lektionen werden kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltenen Lektionen im Rahmen eines kurzen Kolloquiums.

Lecture notes
Dokument: schriftliche Vorbereitung für Prüfungslektionen.

Literature
Wird von der Praktikumslehrperson bestimmt.

ECTS
K

227-0854-00L Mentored Work Subject Didactics Electrical Engineering and Information Technology

Prerequisites: successful completion of FD I and FD II

Abstract
In their mentored work on subject didactics, students apply the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical perspective.

Objective
- The objective is for the students:
  - to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
  - to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Lecture notes
Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.

Literature
K. Frey, Allgemeine Didaktik, FH-Skript bzw. Lehrbuch des Praktikumslehrers.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Electrical Engineering and Information Technology TC - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>W+</th>
<th>W</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>G</th>
<th>U</th>
<th>S</th>
<th>K</th>
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</thead>
<tbody>
<tr>
<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>A</td>
<td>D</td>
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</tr>
<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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</tr>
</tbody>
</table>

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Electrical Engineering and Information Technology Master

Master Studies (Programme Regulations 2018)

Communication

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Communication", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

Core Courses

These core courses are particularly recommended for the field of "Communication". You may choose core courses from other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0121-00L</td>
<td>Communication Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>to be announced</td>
</tr>
</tbody>
</table>

Abstract

Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

Objective

Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

Content

Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

Lecture notes

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Literature


227-0101-00L Discrete-Time and Statistical Signal Processing W 6 credits 4G H.-A. Loeliger

Abstract

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content

1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

Lecture Slides

227-0301-00L Optical Communication Fundamentals W 6 credits 2V+1U+1P J. Leuthold

Abstract

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

Objective

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.
Content

* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.


* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

* Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes

Lecture notes are handed out.

Literature

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

Prerequisites / notice


227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content
The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Communication", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

Number Title Type ECTS Hours Lecturers
227-0102-00L Discrete Event Systems W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes Available
During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesis gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Literature
### Prerequisites
- Basics of digital circuits.

### Examination
- In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

### Further details
- [https://iis-students.ee.ethz.ch/lectures/vlsi-i/](https://iis-students.ee.ethz.ch/lectures/vlsi-i/)

### 227-0166-00L Analog Integrated Circuits
- **Objective**: This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.
- **Content**: Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.
- **Lecture notes**: Handouts of presented slides. No script but an accompanying textbook is recommended.

### 227-0301-00L Optical Communication Fundamentals
- **Objective**: The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.
- **Content**: * Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
  * Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
  * Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
  * Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
  * Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.
- **Lecture notes**: Lecture notes are handed out.
- **Prerequisites / notice**: Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

### 227-0377-10L Physics of Failure and Reliability of Electronic Devices and Systems
- **Objective**: Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.
- **Content**: Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).
- **Lecture notes**: Comprehensive copy of transparencies

### 227-0423-00L Neural Network Theory
- **Abstract**: The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.
- **Objective**: After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. Digital image formation. Image enhancement and feature extraction. Unitary transformations. Color and texture. Image segmentation. Motion extraction and tracking. 3D data extraction. Invariant features. Specific object recognition and object class recognition. Deep learning and Convolutional Neural Networks. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Detailed lecture notes are available on the course web page
https://www.mins.ee.ethz.ch/teaching/ntn/1
Prerequisites / notice
This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

227-0447-00L
Image Analysis and Computer Vision
W 6 credits 3V+1U E. Konukoglu, F. Yu
Abstract
Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions
Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

227-0468-00L
Analog Signal Processing and Filtering
W 6 credits 2V+2U H. Schmid
Suitable for Master Students as well as Doctoral Students.
Abstract
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.
Objective
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.
Content
At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

Lecture notes
The base for these lecture notes are two or three published scientific papers. From these papers we will together develop the technical content.
Prerequisites / notice
Knowledge of the Laplace transform and 2 transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...), and of the main properties of linear systems is necessary.
Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Critical Thinking: assessed
- Creativity: assessed
- Integrity and Work Ethics: not assessed
- Problem-solving: assessed
- Project Management: not assessed

227-0477-00L

Acoustics I

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
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<tbody>
<tr>
<td>K. Heutschi</td>
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</table>

Abstract

Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.

Objective

Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

Content

- Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.

Lecture notes

Yes

Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Problem-solving: assessed

Social Competencies

- Communication: assessed

Personal Competencies

- Creativity: assessed
- Critical Thinking: assessed
- Problem-solving: assessed
- Project Management: not assessed

227-0652-00L

Maxwell, Einstein, and the GPS

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<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>2V+2U</th>
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<tbody>
<tr>
<td>T. Zambelli</td>
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</table>

Abstract

Maxwell’s equations are reinterpreted in the framework of Einstein’s special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

Objective

D-ITET is the depository of the Maxwell’s equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves.

Only one aspect is left over: the fact that they are not invariant with respect to the classical Galilean transformation… On the contrary, Maxwell’s equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell’s equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

Content

- Galileo-Newton, the Ether, Michelson-Morley’s Experiment
- Lorentz Transformations
- 4-Vectors in Minkowski’s Spacetime: Tensor Calculus
- The Lagrangian, the Principle of Stationary Action for Particles and Fields, Noether’s Theorem
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac’s Effect
- GPS

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature

- (Special Relativity) L. Susskind and A. Friedman, “Special Relativity and Classical Field Theory: The Theoretical Minimum”, 2019, Hachette Book Group USA

Supplementary material will be uploaded in Moodle.

+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA
Prerequisites / notice
Notions of a course on Electromagnetism like D-ITET "Electromagnetic Fields and Waves" are indispensable. Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.

IMPORTANT: a few Wednesdays are lectures (NOT exercises!), details in Moodle!

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
- Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-4640-00L Network Security W 8 credits 2V+2U+3A A. Perrig, S. Frei, M. Legner, K. Paterson

Abstract
Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.
The course will cover topics spanning four broad themes with a focus on the first two themes:
(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
(3) analysis and inference topics such as traffic monitoring and network forensics; and
(4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows: In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Students are expected to have a mathematical background and should be able to write rigorous proofs.


This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

At the end of this course, you will
• understand the design of the main building blocks of state-of-the-art digital integrated circuits
• be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
• be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
• understand the performance trade-offs between delay, area, and power consumption
The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

Literature
N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

Prerequisites / notice
VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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</tbody>
</table>

Computers and Networks
The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Computers and Networks", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

Core Courses
These core courses are particularly recommended for the field of "Computers and Networks". You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses
Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>L. Josipovic, L. Vanbever, R. Wattenhofer</td>
</tr>
</tbody>
</table>

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes
Available
Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems FreeRTOS, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html.

The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html.


Advanced Core Courses

Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-2210-00L</td>
<td>Computer Architecture</td>
<td>W</td>
<td>8</td>
<td>6G+1A</td>
<td>O. Mutlu</td>
</tr>
<tr>
<td>Abstract</td>
<td>Computer architecture is the science &amp; art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.</td>
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<tr>
<td>Objective</td>
<td>We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.</td>
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<tr>
<td>Content</td>
<td>The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).</td>
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</table>

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

Lecture notes
All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

The video recordings of the lectures are expected to be made available after lectures.

See https://safari.ethz.ch/architecture for past examples.

Literature
We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

See https://safari.ethz.ch/architecture for past examples.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0575-00L</td>
<td>Advanced Topics in Communication Networks</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>L. Vanbever, R. Jacob</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover advanced topics in Internet routing and forwarding.</td>
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<td>Objective</td>
<td>The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be &quot;hands-on&quot; and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.</td>
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<tr>
<td>Content</td>
<td>The course will cover advanced topics in Internet routing and forwarding such as:</td>
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<td></td>
<td>- Tunneling</td>
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<td></td>
<td>- Hierarchical routing</td>
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<td></td>
<td>- Traffic Engineering and Load Balancing</td>
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<td></td>
<td>- Virtual Private Networks</td>
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<td></td>
<td>- Quality of Service/Queuing/Scheduling</td>
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<td>- Fast Convergence</td>
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<td></td>
<td>- Network virtualization</td>
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<td>- Network programmability (OpenFlow, P4)</td>
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<td>- Network measurements</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes and material will be made available before each course on the course website.</td>
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<tr>
<td>Literature</td>
<td>Relevant references will be made available through the course website.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Communication Networks (227-0120-00L) or equivalents / good programming skills (in any language) are expected as both the exercises and the final project will involve coding.</td>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories assessed</td>
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<td></td>
<td>Techniques and Technologies assessed</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies assessed</td>
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<td>Decision-making assessed</td>
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<td>Problem-solving assessed</td>
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<td>Project Management assessed</td>
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<td>Social Competencies</td>
<td>Communication assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility assessed</td>
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<td>Creative Thinking assessed</td>
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<td></td>
<td>Critical Thinking assessed</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0579-00L</td>
<td>Hardware Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>K. Razavi</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.</td>
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</table>

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

Lecture notes and material will be made available before each course on the course website.

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture
Objective

By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:

- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.
- writing critical reviews and constructive discussions with peers on this topic.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature

Slides, relevant literature and manuals will be made available during the course.

Prerequisites / notice

Experience with Linux, systems programming and computer architecture.

---

252-1414-00L System Security

W  7 credits  2V+2U+2A  S. Capkun, S. Shinde

Objective

In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content

The first part of the lecture covers individual system's aspects starting with tamperproof or tamperresistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

---

263-4640-00L Network Security

W  8 credits  2V+2U+3A  A. Perrig, S. Frei, M. Legner, K. Paterson

Objective

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content

The course will cover topics spanning four broad themes with a focus on the first two themes:

- network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
- network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
- analysis and inference topics such as traffic monitoring and network forensics; and
- new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Taught competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

---

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Computers and Networks", but you are free to choose courses from any other field in agreement with your tutor.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 883 of 2345
## 227-0101-00L Discrete-Time and Statistical Signal Processing

### Abstract
The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

### Objective
The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

### Content
1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum,
   - decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   - probability, random variables, discrete-time stochastic processes;
   - detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
   - Wiener filter, LMS adaptive filter, Viterbi algorithm.

### Literature

### Prerequisites / notice
Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

---

## 227-0103-00L Control Systems

### Abstract
Study of control systems for single input - single output and multivariable systems.

### Objective

### Literature

### Prerequisites / notice
Prerequisites: Signal and Systems Theory II.

---

## 227-0116-00L VLSI 1: HDL Based Design for FPGAs

### Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

### Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

### Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog.
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

### Literature
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

Abstract
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective
Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes
Comprehensive copy of transparencies

Literature

227-0377-10L

Physics of Failure and Reliability of Electronic Devices and Systems

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
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<tbody>
<tr>
<td>I. Shorubalko, M. Held</td>
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</table>

Abstract
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective
Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes
Comprehensive copy of transparencies

Literature

227-0447-00L

Image Analysis and Computer Vision

<table>
<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>3V+1U</th>
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<tbody>
<tr>
<td>E. Konukoglu, F. Yu</td>
<td></td>
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</table>

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Prerequisites:
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

227-0555-00L

Distributed Systems

<table>
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<tr>
<th>W</th>
<th>4 credits</th>
<th>3G+1A</th>
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<tbody>
<tr>
<td>R. Wattenhofer</td>
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</table>

Abstract
This course introduces the fundamentals of distributed systems. We study different protocols and algorithms that allow for fault-tolerant operation, and discuss practical systems that implement these techniques.

Objective
The objective of the course is for students to understand the theoretical principles and practical considerations of distributed systems. This includes the main models of fault-tolerant distributed systems (crash failures, byzantine failures, and selfishness), and the most important algorithms, protocols and impossibility results. By the end of the course, students should be able to reason about various concepts such as consistency, durability, availability, fault tolerance, and replication.

Content
We discuss the following concepts related to fault-tolerant distributed systems: client-server, serialization, two-phase protocols, three-phase protocols, Paxos, two generals problem, crash failures, impossibility of consensus, Byzantine failures, agreement, termination, validity, Byzantine agreement, King algorithm, asynchronous Byzantine agreement, authentication, signatures, reliable and atomic broadcast, eventual consistency, blockchain, cryptocurrencies such as Bitcoin and Ethereum, proof-of-work, proof-of-*, smart contracts, quorum systems, fault-tolerant protocols such as pChain or pBFT, distributed storage, distributed hash tables, physical and logical clocks, causality, selfishness, game theoretic models, mechanism design.

Lecture notes
A script is available on the web page.

Literature
The script is self-contained, but links to additional material are available on the web page.

Prerequisites / notice
This lecture takes place in roughly the second half of the semester, as the lecture is the second part of the lecture “Computer Systems” (252-0217-00). Students may attend at most one of the two lectures, NOT both.

227-2211-00L

Seminar in Computer Architecture

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<tr>
<th>W</th>
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<tr>
<td>O. Mutlu, M. H. K. Alser, J. Gomez Luna</td>
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</tbody>
</table>

Abstract
In this seminar course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of multiple components that are aimed at improving students’ technical skills in computer architecture, critical thinking and analysis on computer architecture concepts, as well as technical presentation of concepts and papers in both spoken and written forms.

Objective
The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report per each student at the end of the semester.

This course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles.

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure \( A \) one maps its elements to vectors in a linear space, and shows that the set \( A \) is mapped to a small linear subspace.

This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Content**

- Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

**Objective**

- Familiarize students with main architectural principles and concepts of embedded control systems.
- An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

**Content**

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse with modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

**Prerequisites / notice**

- Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice.

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### 151-0593-00L Embedded Control Systems

**Abstract**

This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

**Objective**

- Familiarize students with main architectural principles and concepts of embedded control systems.
- An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

**Content**

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse with modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

**Lecture notes**

Lecture notes, lab instructions, supplemental material

**Prerequisites / notice**

- Prerequisite courses are Control Systems I and Informatics I.
- Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice.

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### 252-1411-00L Security of Wireless Networks

**Abstract**

- Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.
- After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.
- Content


**Prerequisites / notice**

- This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: mariansmn@ethz.ch)
- After your reservation has been confirmed please register online at www.mystudies.ethz.ch.
- Detailed information can be found on the course website http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

### 401-3055-64L Algebraic Methods in Combinatorics

**Abstract**

- Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.
- Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

- Content

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure \( A \) one maps its elements to vectors in a linear space, and shows that the set \( A \) is mapped to a small linear subspace.

This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidian space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app22.ethz.ch/course/view.php?id=15757

**Prerequisites / notice**

- Students are expected to have a mathematical background and should be able to write rigorous proofs.
Electronics and Photonics

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Electronics and Photonics", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

Core Courses

These core courses are particularly recommended for the field of "Electronics and Photonics". You may choose core courses from other fields in agreement with your tutor.

Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0110-00L</td>
<td>Electromagnetic Waves: Materials, Effects, and Antennas</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

Abstract
This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.

Objective
You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions.
You know how waves interact with matter and about nonlinear and resonant effects.
You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.

Content
The lecture covers the following topics:
- Generic time-harmonic electromagnetic fields
- Fundamental solutions of the wave equation
- Wave propagation in various types of materials
- Interaction of waves with matter
- Nonlinear effects
- Resonant effects
- Applications like scattering, waveguiding, radiation
- Radio frequency and optical antennas

Lecture notes
Lecture notes and slides will be handed out during the lectures.

Prerequisites / notice
Remark: the lecture succeeds «Advanced Electromagnetic Waves» and reorients itself to materials, effects, and applications with waves.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>F. K. Gürkaynak, L. Benini</td>
</tr>
</tbody>
</table>

Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
  - Register Transfer Level (RTL) synthesis and its limitations.
  - Building blocks of digital VLSI circuits.
  - Functional verification techniques and their limitations.
  - Modular and largely reusable testbenches.
  - Assertion-based verification.
  - Synchronous versus asynchronous circuits.
  - The case for synchronous circuits.
  - Periodic events and the Anceau diagram.
  - Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Prerequisites / notice

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-1/

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<th>Number</th>
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<tbody>
<tr>
<td>227-0145-00L</td>
<td>Solid State Electronics and Optics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>N. Yazdani, V. Wood</td>
</tr>
</tbody>
</table>

Abstract
“Solid State Electronics” is an introductory condensed matter physics course covering crystal structure, electron models, classification of metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and optical properties of solids.

Objective
Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems. The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; frequency synthesizers; switched capacitor circuits. The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Handouts of presented slides. No script but an accompanying textbook is recommended.


Advanced Core Courses

Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecture notes</th>
<th>Literature</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0146-00L</td>
<td>Analog-to-Digital Converters</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>Slides are available online under <a href="https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/">https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/</a></td>
<td>B. Razavi, Principles of Data Conversion System Design, IEE, Press, 1994</td>
<td>It is highly recommended to attend the course &quot;Analog Integrated Circuits&quot; of Prof. T. Jang as a preparation for this course.</td>
</tr>
</tbody>
</table>
Nonlinear Optics

Abstract
Nonlinear Optics deals with the interaction of light with material, the response of material to light and the mathematical framework to describe the phenomena. As an example we will cover fundamental phenomena such as the refractive index, the electro-optic effect, second harmonic generation, four-wave mixing or soliton propagation and others.

Objective
The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematically by means of the susceptibility.

Content
Chapter 1: The Wave Equations in Nonlinear Optics
Chapter 2: Nonlinear Effects - An Overview
Chapter 3: The Nonlinear Optical Susceptibility
Chapter 4: Second Harmonic Generation
Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator
Chapter 6: Acousto-Optic Effect
Chapter 7: Nonlinear Effects of Third Order
Chapter 8: Nonlinear Effects in Media with Gain

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics

Nano-Optics

Abstract
Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Objective
Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

Content
We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

Prerequisites / notice
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

VLSI 3: Full-Custom Digital Circuit Design

Abstract
This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

Objective
At the end of this course, you will
- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

Content
The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:
- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
-Latch and flip-flop circuits
-Gate-level timing analysis and optimization
-Static and dynamic power consumption; low-power techniques
-Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
-Arithmetic and logic circuits
-Fixed-point and floating-point arithmetic
-Synchronous and asynchronous design principles
-Memory circuits (ROM, SRAM, and DRAM)
-In- and near-memory processing architectures
-Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

Prerequisites / notice
VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Specialisation Courses

These specialisation courses are particularly recommended for the area of “Electronics and Photonics”, but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master’s Programme.

Number Title Type ECTS Hours Lecturers

227-0121-00L Communication Systems W 6 credits 4G to be announced

Abstract
Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

Objective
Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems
Machine Learning on Microcontrollers

Registration in this class requires the permission of the instructors. Class size will be limited to 25. Preference is given to students in the MSC EEIT.

Abstract
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

Objective
Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras,...). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

Content
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercises will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Lecture notes
Script and exercise sheets. Books will be suggested during the course.

Prerequisites / notice

Semiconductor Devices: Physical Bases and Simulation

The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

Objective
The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

Content
The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic modeling), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

Analog Integrated Circuits

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

Content
Review of bipolar and MOS devices and their small-signal equivalent circuit models. Building blocks in analog circuits such as current sources, active load, common emitters, supply independent biasing etc; Amplifiers, differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

Physics of Failure and Reliability of Electronic Devices and Systems

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Comprehensive copy of transparencies


227-0468-00L Analog Signal Processing and Filtering

Suitable for Master Students as well as Doctoral Students.

W 6 credits 2V+2U H. Schmid

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

227-0615-00L Simulation of Photovoltaic Devices - From Materials to Modules

W 3 credits 2G U. Aebenerhard

The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules and large scale photovoltaic systems.

Get an overview over the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to predict the performance of solar cells and modules.
Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)
**Objective**

By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolysers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

**Literature**


R. Huggins, Advanced Batteries, DOI:10.1007/9780387764245

**Prerequisites / notice**

Be motivated to change the world to renewable energies! Elements of calculus will be reviewed at the beginning of the course, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite. Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students. A visit to a solar cell or battery fab will be organized during the semester if the epidemiological situation permits.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>W credits</th>
<th>E credits</th>
<th>T. Zambelli</th>
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<tbody>
<tr>
<td>227-0652-00L</td>
<td>Maxwell, Einstein, and the GPS</td>
<td>W 6</td>
<td>6</td>
<td>T. Zambelli</td>
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**Abstract**

Maxwell’s equations are reinterpreted in the framework of Einstein’s special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

**Content**

- Galileo-Newton, the Ether, Michelson-Morley's Experiment
- Lorentz Transformations
- 4-Vectors in Minkowski’s Spacetime: Tensor Calculus
- The Lagrangian, the Principle of Stationary Action for Particles and Fields, Noether’s Theorem
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac’s Effect
- GPS

**Lecture notes**

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

**Literature**

- (Special Relativity) L. Susskind and A. Friedman, “Special Relativity and Classical Field Theory: The Theoretical Minimum”, 2019, Hachette Book Group USA

Supplementary material will be uploaded in Moodle.

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+ (on the GPS) E.D. Kaplan, C. Hegarty, "Understanding GPS/GNSS", 2017, ARTECH HOUSE USA


Notions of a course on Electromagnetism like D-ITET "Electromagnetic Fields and Waves" are indispensable.

Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.

**Prerequisites / notice**

IMPORTANT: a few Wednesdays are lectures (NOT exercises!), details in Moodle!

**Taught competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Assessed</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</tbody>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 893 of 2345
227-0653-00L  Electromagnetic Precision Measurements and Opto-Mechanics  
W  4 credits  2V+1U  M. Frimmer

Abstract
The measurement process is at the heart of both science and engineering. Electromagnetic fields have proven to be particularly powerful probes. This course provides the basic knowledge necessary to understand current state-of-the-art optomechanical measurement systems operating at the precision limits set by the laws of quantum mechanics.

Objective
The goal of this course is to understand the fundamental limitations of measurement systems relying on electromagnetic fields.

Content
The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics.

Prerequisites / notice
1. Electrodynamics
2. Physics 1.2
3. Introduction to quantum mechanics

227-0659-00L  Integrated Systems Seminar  
W  1 credit  1S  M. Luisier

Abstract
In the "Fachseminar IIS" the students learn to communicate topics, ideas or problems of scientific research by listening to more experienced authors and by presenting scientific work in a conference-like situation for a specific audience.

Objective
The seminar aims at instructing graduate and PhD students in the basics of presentation techniques, i.e. "how to give a professional talk". Attendees have the possibility to become acquainted with a current topic by a literature study, and to present the results thereof in a 20 minutes talk in English. The participation at the seminar gives also an overview on current problems in modern nano- and opto-electronics.

Content
The seminar topics are simulation of nanoelectronic processes and devices, and the optical as well as electronic simulation of optoelectronic devices as lasers, photodiodes, etc.

Lecture notes
The students learn how to find the right literature for a certain topic quickly, as well as how to prepare a talk for a scientific conference, i.e. presentation techniques.

227-0665-00L  Battery Integration Engineering  
W  3 credits  2V+1U

Abstract
Batteries enable sustainable mobility, renewable power integration, various power grid services, and residential energy storage. Linked with low cost PV, Li-ion batteries are positioned to shift the 19th-century centralized power grid into a 21st-century distributed one. As with battery integration, this course combines understanding of electrochemistry, heat & mass transfer, device engineering.

Objective
The learning objectives are:
- Apply critical thinking on advancements in battery integration engineering. Assessment reflects this objective and is based on review of a scientific paper, with mark weighting of 10 / 25 / 65 for a proposal / oral presentation / final report, respectively.
- Design battery system concepts for various applications in the modern power system and sustainable mobility, with a deep focus on replacing diesel buses with electric buses combined with charging infrastructure.
- Critically assess progresses in battery integration engineering: from material science of novel battery technologies to battery system design.
- Apply “lessons learned” from the history of batteries to assess progress in battery technology.
- Apply experimental and physical concepts to develop battery models in order to predict lifetime.
- Battery systems for the modern power grid and sustainable mobility.
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.
- Sustainability and life cycle analysis of battery system innovations.

Prerequisites / notice
Limited to 30 Students. Priority given to Electrical and Mechanical Engineering students.

Mandatory - background knowledge in batteries & electrochemistry acquired in one of the following courses:
- 227-0664-00L Technology and Policy of Electrical Energy Storage
- 529-0440-00L Physical Electrochemistry and Electrocatalysis
- 529-0191-01L Renewable Energy Technologies II, Energy Storage and Conversion
- 529-0659-00L Electrochemistry (Exception for PhD students).

Exception given for PhD students

227-0621-00L  Emerging Memory Technologies  
W  3 credits  1V+1U  M. Yarema

Abstract
The course covers the status and prospects of post-silicon memory technologies, such as PCM, RRAM, STT-MRAM and FeRAM, and others. Students learn and compare these future memory technologies by means of interactive lectures, group projects, and laboratory sessions. The course employs constructive alignment and active learning teaching concepts.
Objective

Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict them at least niche applications for ever-growing hardware market. However, some of these technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now.

Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other’s. Selecting to study one technology in more details, students will evaluate its potential and acquire important presenting and critical thinking skills.

Content

The course is organized as a series of lectures, which are synchronized with student group projects, focusing on selected memory technologies. Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 3 presentations (20-25 min each), followed the example given by the lecturer.

Literature

Lecture notes will be made available on the website.

<table>
<thead>
<tr>
<th>Module</th>
<th>Notes</th>
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<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
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<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
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<tr>
<td>227-2211-00L</td>
<td>Seminar in Computer Architecture</td>
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</table>

**Objective**

- **Neuromorphic Engineering I**
  - Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict them at least niche applications for ever-growing hardware market. However, some of these technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now.
  - Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other’s. Selecting to study one technology in more details, students will evaluate its potential and acquire important presenting and critical thinking skills.

**Content**

- The course is organized as a series of lectures, which are synchronized with student group projects, focusing on selected memory technologies. Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 3 presentations (20-25 min each), followed the example given by the lecturer.

**Literature**

Lecture notes will be made available on the website.

**227-1033-00L Neuromorphic Engineering I**

- **W 6 credits**
- **2V+3U**
- T. Delbrück, G. Indiveri, S.-C. Liu

**Abstract**

Information for UZH students:

Enrolment to this course unit only possible at ETH. No enrolment to module IN4044 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

**Objective**

Understanding of the characteristics of neuromorphic circuit elements.

**Content**

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Literature**

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

**Prerequisites / notice**

Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

**227-2037-00L Physical Modelling and Simulation**

- **W 6 credits**
- **4G**
- J. Smajic

**Abstract**

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

**Objective**

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

**Content**

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

**Prerequisites**

Background in basics of semiconductor physics helpful, but not required.

**227-2211-00L Seminar in Computer Architecture**

- **W 2 credits**
- **2S**
- O. Mutlu, M. H. K. Alser, J. Gómez Luna

**Abstract**

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

**Objective**

The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report delivered by each student at the end of the semester.

**Content**

Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

See https://safari.ethz.ch/architecture_seminar for past examples.
Robots are often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

## 151-0601-00L Theory of Robotics and Mechatronics

**Abstract**
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**
Robots are often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**
Available.

**Literature**
Nanosystems

**Prerequisites / notice**
See https://safari.ethz.ch/architecture_seminar for past examples.

## 151-0620-00L Embedded MEMS Lab

**Abstract**
Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access.

**Objective**
Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

**Content**
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

**Lecture notes**
A document containing theory, background and practical course content is distributed at the introductory lecture day of the course.

**Literature**
The document provides sufficient information for the participants to successfully participate in the course.

**Prerequisites / notice**
Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Kourmoutakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.
The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale
Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.
Self-assembly and directed assembly of 2D and 3D structures.


Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

Lectures and Mini-Review presentations: Thursday 10-13

Homework: Mini-Review
(compulsory continuous performance assessment)

363-0389-00L Technology and Innovation Management W 3 credits 2G S. Brusoni, A. Zeijen

Abstract
This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, guest speakers, simulations and group work.

Objective
This course intends to enable all students to:
- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyze the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

Content
This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, guest speakers, simulations and group work.

Lecture notes
Readings will be available on the Moodle page

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Critical Thinking assessed

376-1176-00L Wearable and Mobile Technologies of the Future - Focus on Sports and Health W 4 credits 3G C. Menon, C. Ahmadizadeh, M. Eiligendi

Number of participants limited to 60

Abstract
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Technique and Innovation Management
30 credits

Wearable and Mobile Technologies of the Future - Focus on Sports and Health
22 credits

Technology and Innovation Management
3 credits

Chemical Physics of Materials
14 credits

Molecular Physics of Materials
12 credits

Molecular Physics of Materials
22 credits
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

Objective 1: Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: Acquire skills to design novel non-invasive technologies for sport and health.

Title
Abstract
Objective
Lecture notes
Prerequisites / notice

401-3055-64L Algebraic Methods in Combinatorics
Does not take place this semester.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.
Students are expected to have a mathematical background and should be able to write rigorous proofs.

Energy and Power Electronics
The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Energy and Power Electronics", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.
The individual study plan is subject to the tutor's approval.

Core Courses
These core courses are particularly recommended for the field of "Energy and Power Electronics". You may choose core courses from other fields in agreement with your tutor.
A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses
Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<td>227-0113-00L</td>
<td>Power Electronics</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>J. W. Kolar</td>
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Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 898 of 2345
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Lecture notes
Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites
Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation

Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Content
- Fundamentals of magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Abstract
This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

Objective
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

227-0517-10L Fundamentals of Electric Machines W 6 credits 4G D. Bortis

Advanced Core Courses
Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

Number Title Type ECTS Hours Lecturers
227-0117-00L High Voltage Engineering W 6 credits 4G C. Franck, U. Straumann

Abstract
High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, .... High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages.

Objective
The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify of weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

Content
- discussion of the field equations relevant for high voltage engineering.
- analytical and numerical solutions/solving of this equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components

Lecture notes
Lecture Slides

Literature
The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis methods of large linear and non-linear systems of equations related to electrical power networks.

Content
- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes
Lecture notes and associated exercises including correct answers

227-0526-00L Power System Analysis W 6 credits 4G G. Hug

Abstract
The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis tools in steady and dynamic states.

Objective
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes
Lecture notes.

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Energy and Power Electronics", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>
The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust “inversion” of a linear filter.

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Literature**

**Prerequisites / notice**

MATLAB is used for system analysis and simulation.

**Lecture notes**

**Literature**

**Prerequisites / notice**

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Problem-solving
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

**Method-specific Competencies**

- assessed
- assessed
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- not assessed
- not assessed

**Personal Competencies**

- assessed
- assessed
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- not assessed
- not assessed

**Tuught competencies**

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Literature**

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**Lecture notes**

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**Lecture notes**

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**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Subject-specific Competencies**

- Concepts and Theories
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**Method-specific Competencies**

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**Personal Competencies**

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**Tuught competencies**

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Literature**

**Prerequisites / notice**

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Problem-solving
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- Critical Thinking
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**Method-specific Competencies**

- assessed
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**Personal Competencies**

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**Tuught competencies**

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Literature**

**Prerequisites / notice**

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Subject-specific Competencies**

- Concepts and Theories
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**Method-specific Competencies**

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**Personal Competencies**

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**Tuught competencies**

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Literature**

**Prerequisites / notice**

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Subject-specific Competencies**

- Concepts and Theories
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**Method-specific Competencies**

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**Tuught competencies**

**Abstract**

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**Content**

**Lecture notes**

**Literature**

**Prerequisites / notice**

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies
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**Personal Competencies**

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**Tuught competencies**

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**Lecture notes**

**Literature**

**Prerequisites / notice**

**Lecture notes**

Available on the course Moodle platform.

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**Subject-specific Competencies**

- Concepts and Theories
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**Tuught competencies**

**Abstract**

**Objective**

**Content**

**Lecture notes**

**Literature**

**Prerequisites / notice**

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.
Abstract
This course introduces different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

Objective
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

Content
- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes
Lecture notes and associated exercises including correct answers

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<th>Code</th>
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<th>4 credits</th>
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<td>Railway Systems I</td>
<td></td>
<td></td>
<td></td>
<td>M. Meyer</td>
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<td></td>
<td>- Transportation tasks and vehicle types</td>
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<td></td>
<td>- Running dynamics</td>
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<td></td>
<td>- Mechanical part of rail vehicles</td>
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<td>- Brakes</td>
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<td>- Traction chain and auxiliary supply</td>
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<td>- Railway power supply</td>
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<td>- Signalling systems</td>
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<td>- Standards</td>
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<td>- Availability and safety</td>
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<td>- Traffic control and maintenance</td>
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<td>Objective</td>
<td>Overview of the technical characteristics of railway systems</td>
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<td></td>
<td>- Know-how about the design and construction principles of rail vehicles</td>
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<td></td>
<td>- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)</td>
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<td></td>
<td>- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries</td>
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<td>- Insight into the activities of the railway vehicle industry and railway operators in Switzerland</td>
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<td></td>
<td>- Motivation of young engineers to start a career in the railway industry or with railway operators</td>
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</table>

EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrdynamik
2 Vollbahnfahrzeuge:
2.1 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebsysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung
3 Infrastruktur:
3.1 Fahrweg
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen
4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
Betriebszentrale SBB, Zürich Flughafen
Reparatur und Unterhalt, SBB Zürich Altstetten
Fahrzeugfertigung, Stadler Bussnang

Lecture notes
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice
Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Personal Competencies
Critical Thinking

227-0536-00L Multiphysics Simulations for Power Systems

This course is defined so and planned to be an addition to the module “227-0537-00L Technology of Electric Power System Components”.

However, the students who are familiar with the fundamentals of electromagnetic fields could attend only

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 902 of 2345
**Abstract**
The goals of this course are a) understanding the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations and b) performing effective simulations of primary equipment of electric power systems. The course is understood complementary to 227-0537-00L “Technology of Electric Power System Components”, but can also be taken separately.

**Objective**
The student should learn the fundamentals of the electromagnetic, thermal, mechanical, and coupled fields simulations necessary for modern product development and research based on virtual prototyping. She / he should also learn the theoretical background of the finite element method (FEM) and its application to low- and high-frequency electromagnetic field simulation problems. The practical exercises of the course should be done by using one of the commercially available field simulation software (Infolytica, ANSYS, and / or COMSOL).

After completing the course the student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.

**Content**
1. Electromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
   a. Short review of the governing equations
   b. Boundary conditions
   c. Initial conditions
   d. Linear and nonlinear material properties
   e. Coupled fields (electro-mechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgears (GIS)
   f. Electromagnetic compatibility (EMC)

**Prerequisites / notice**
Lecture notes and supplementary exercises including correct answers.

**Literature**
- B. J. Baliga: "Physics Modern Power Devices"
- M. P. M. Ciappa: "Electrical Engineering and Computer Science in Power Electronics and Drives"
- F. Krismer
- S. K. Ghandi: "Semiconductor Power Devices"
Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries.

Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.

Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text); PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.

Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.

Lecture notes
Slides will be available as .PDF documents, see "Learning materials" (for registered students only)

Literature
References will be given at the end of individual lectures.

Prerequisites / notice
Exercises: Tuesday 15-16
Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

227-0731-00L Power Market I - Portfolio and Risk Management W 6 credits 4G D. Reichelt, G. A. Koeppel
Abstract
Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

Objective

Content
1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions

3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

Lecture notes
Handouts of the lecture
Prerequisites / notice
1 excursion per semester, 2 case studies, guest speakers for specific topics.
Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

Systems and Control
The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Systems and Control", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

Core Courses
These core courses are particularly recommended for the field of "Systems and Control". You may choose core courses from other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses
Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
</tbody>
</table>

Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.
Advanced Core Courses

Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>J. Lygeros, A. Tsiamis</td>
</tr>
<tr>
<td>227-0697-00L</td>
<td>Industrial Process Control</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Horch, L. Dominguez Palomeque</td>
</tr>
<tr>
<td>151-0371-00L</td>
<td>Advanced Model Predictive Control</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>M. Zeillinger, A. Carron, L. Hewing, J. Köhler</td>
</tr>
</tbody>
</table>

Abstract

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes

Available on the course Moodle platform.

Prerequisites / notice

Sufficient mathematical maturity, in particular in linear algebra, analysis.

Prerequisites / notice

Lecture notes

Slides will be available as PDF documents, see "Learning materials" (for registered students only)

Prerequisites / notice

References will be given at the end of individual lectures.

Evaluation

Exercises: Tuesday 15-16

Lecture notes

Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

Content

Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

Objective

Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

Content

- Topics include
  - Review of Bayesian statistics, stochastic systems and Stochastic Optimal Control
  - Nominal MPC for uncertain systems (nominal robustness)
  - Robust MPC
  - Stochastic MPC
  - Set-membership Identification and robust data-driven MPC
  - Bayesian regression and stochastic data-driven MPC
  - MPC as safety filter for reinforcement learning

Lecture notes

Lecture notes will be provided.

Prerequisites / notice

Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended.

Background in linear algebra and stochastic systems recommended.
Abstract

Introduction to Dynamic Programming and Optimal Control.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature


Prerequisites / notice

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Systems and Control", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>L. Josipovic, L. Vanbever, R. Wattenhofer</td>
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</tbody>
</table>

Abstract

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content

1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Literature

[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv
Cambridge University Press, 1998

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger
D. Hochbaum

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitsrechnung und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser

227-0447-00L | Image Analysis and Computer Vision | W | 6 | 3V+1U | E. Konukoglu, F. Yu |

Abstract


Objective

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice

Prerequisites:

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Week</th>
<th>Credits</th>
<th>Prerequisites / Notice</th>
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<tbody>
<tr>
<td>227-0526-00L</td>
<td>Power System Analysis</td>
<td>W</td>
<td>6</td>
<td>Control systems (227-0216-00L) or equivalent.</td>
</tr>
<tr>
<td>227-0689-00L</td>
<td>System Identification</td>
<td>W</td>
<td>4</td>
<td>Control systems (227-0216-00L) or equivalent.</td>
</tr>
<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3</td>
<td>to be announced</td>
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</table>

Autumn Semester 2022

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151-0532-00L **Nonlinear Dynamics and Chaos I**  
W 4 credits 2V+2U  G. Haller

**Abstract**  
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

**Objective**  
This course is intended for masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

**Content**  
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

**Lecture notes**  
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

**Prerequisites / notice**  
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

151-0573-00L **System Modeling**  
W 4 credits 2V+1U  L. Guzzella

**Abstract**  
Introduction to system modeling for control. Generic modeling approaches based on first principles, Lagrangian formalism, energy approaches and experimental data. Model parametrization and parameter estimation. Basic analysis of linear and nonlinear systems.

**Objective**  
Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.

**Content**  
This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.

**Lecture notes**  
The handouts in English will be available in digital form.

**Literature**  
A list of references is included in the handouts.
### Theory of Robotics and Mechatronics

**W 4 credits 3G**

*Does not take place this semester.*

**Abstract**

This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**

Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**

An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**

available.

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### Dynamic Programming and Optimal Control

**W 4 credits 2V+1U**

*R. D’Andrea*

**Abstract**

Introduction to Dynamic Programming and Optimal Control.

**Objective**

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

**Literature**


**Prerequisites / notice**

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

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### Applied Compositional Thinking for Engineers II

**E- 4 credits 3G**

*A. Censi, J. Lorand*

**Abstract**

This course is an introduction to advanced topics in Applied Category Theory focused on the need of applications. The course favors a computational, constructive, and compositional approach targeted to specific applications in engineering.

**Objective**

In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of the problem and the design of the solution. However, the problem is that the type of math which could be useful to applications is not traditionally taught. Applied Category Theory is a new field of mathematics that could help thinking about compositionality.

However, there exists no easy path for learning it for engineers that is approachable and shows practical applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I), offered in Spring 2021.

This course's goal is not to teach category theory for the sake of it. Rather, we will teach the "compositionality way of thinking"; category theory will be just the means towards it. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.

The course will favor a computational/constructive approach, highlighted even more in the second part of the class: each concept is accompanied by concrete exercises in the programming language Python.

The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.

**Content**

Categories

- Functors
- Co-design problems
  - Naturality:
    - Natural transformations
    - Adjunctions
    - Traced monoidal categories
  - Computation:
    - From mathematical models to algorithms
    - Solving finite co-design problems
    - Monads
    - Modeling uncertainty
- Enriched category theory:
  - Profunctors
  - Enriched categories
  - Negative category theory
- Wirings:
  - Operads
  - Wiring diagrams
- Linear logic
  - Linear logic and DP

**Lecture notes**

Slides and notes will be provided.

**Literature**


**Prerequisites / notice**

The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Algebra (sets, posets, relations, semigroups, groups).
3) Python programming.

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in Spring Semester are sufficiently proficient in (1)-(3).

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### Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

**W 3 credits 2V**

*R. Rienner, O. Lambercy*

**Abstract**

Autumn Semester 2022

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Autumn Semester 2022  
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Abstract
Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
- Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
- Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature
Introductory Books:

Selected Journal Articles and Web Links:


VideoTact, ForeThought Development, LLC. http://my.execpc.com/?dwysocki/videotac.html
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Communication

Key topics include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Information about relevant literature will be given in the lecture.

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

Solid background in linear algebra.

Concepts and Theories


Computational Systems Biology


Computational methods for the modeling, simulation and analysis of biological networks. The aim of this course is to provide an introductory overview of computational methods for the modeling, simulation and analysis of biological networks.

- Modelling with mathematical optimization: applications of mathematical programming in engineering.
- Modelling with mathematical optimization: applications of mathematical programming in engineering.
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

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Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstelensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

Lecture notes will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely. Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Signal Processing and Machine Learning

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of **"Signal Processing and Machine Learning"**, see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

### Core Courses

These core courses are particularly recommended for the field of **"Signal Processing and Machine Learning"**. You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

### Foundation Core Courses

*Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.*

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<th>Number</th>
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<th>ECTS</th>
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<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
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<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
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**Autumn Semester 2022**
### Advanced Core Courses

**Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.**

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<td>4</td>
<td>2V+1U</td>
<td>H. Bölcskei</td>
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<td>3V+1U</td>
<td>E. Konukoglu, F. Yu</td>
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<td>The course language is English.</td>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrin Jimenez</td>
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<td>Machine learning algorithms provide</td>
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<td>analytical methods to search data</td>
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<td>sets for characteristic patterns.</td>
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<td>Typical tasks include the</td>
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<td>classification of data, function</td>
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<td>fitting and clustering, with</td>
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<td>applications in image and speech</td>
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<td>analysis, bioinformatics and</td>
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<td>exploratory data analysis. This</td>
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<td>course is accompanied by practical</td>
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<td>machine learning projects. Students</td>
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<td>concepts and algorithms for</td>
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<td>supervised and unsupervised learning;</td>
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<td>reinforce the statistics knowledge</td>
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<td>which is indispensable to solve</td>
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<td>Key concepts are the generalization</td>
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<td>ability of algorithms and</td>
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<td>systematic approaches to modeling</td>
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<td>and regularization. Machine</td>
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<td>learning projects will provide an</td>
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<td>opportunity to test the machine</td>
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<td>learning algorithms on real world</td>
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</table>
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz.
Number of participants limited to 320.
Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.
Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://ias.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://mi2.in.tum.de/courses/tlt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

401-4944-20L Mathematics of Data Science W 8 credits 4G A. Bandeira
Abstract
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.
Objective
Introduction to various mathematical aspects of Data Science.
Content
These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

Lecture notes
The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Signal Processing and Machine Learning", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the MSc EEIT.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>F. K. Gürkaynak, L. Benini</td>
</tr>
</tbody>
</table>

Abstract

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aim of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register transfer level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes

Textbook and all further documents in English.

Literature


Prerequisites / notice

Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details:
https://iis.students.ee.ethz.ch/lectures/vlsi-i/

227-0155-00L    Machine Learning on Microcontrollers ■ W 6 credits 4G M. Magno, L. Benini

Registration in this class requires the permission of the instructors. Class size will be limited to 25. Preference is given to students in the MSc EEIT.

Abstract

Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

Objective

Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras...). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems

- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)

- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.

- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercises will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

To be announced

### Literature


### Lecture Slides

Script and exercise sheets. Books will be suggested during the course.

### Prerequisites / notice

Exposure to machine learning concepts is also desirable

<table>
<thead>
<tr>
<th>227-0121-00L</th>
<th>Communication Systems</th>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>to be announced</th>
<th>A. Lapidoth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems</td>
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<tr>
<td><strong>Content</strong></td>
<td>Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.</td>
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### Lecture slides

Available on the course Moodle platform.

### Prerequisites / notice

Sufficient mathematical maturity, in particular in linear algebra, analysis.

### Taught competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Problem-solving

**Personal Competencies**
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

<table>
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<tr>
<th>227-0225-00L</th>
<th>Linear System Theory</th>
<th>W</th>
<th>6 credits</th>
<th>5G</th>
<th>J. Lygeros, A. Tsiamis</th>
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<tr>
<td><strong>Abstract</strong></td>
<td>The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Proof techniques and practices.</td>
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</table>
- Linear spaces, normed linear spaces and Hilbert spaces. |
- Ordinary differential equations, existence and uniqueness of solutions. |
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case. |
- Controllability and observability, duality. Time invariant systems treated as a special case. |
- Stability and stabilization, observers, state and output feedback, separation principle. |

### Lecture notes

Available on the course Moodle platform.

### Taught competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Problem-solving

**Personal Competencies**
- Critical Thinking
- Integrity and Work Ethics

<table>
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<tr>
<th>227-0417-00L</th>
<th>Information Theory I</th>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>A. Lapidoth</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The fundamentals of Information Theory including Shannon's source coding and channel coding theorems</td>
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<tr>
<td><strong>Content</strong></td>
<td>The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity</td>
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### Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

<table>
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<tr>
<th>227-0421-00L</th>
<th>Deep Learning in Artificial and Biological Neuronal Networks</th>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>B. Grewe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.</td>
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The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g., simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

After this course students will be able to:
- train basic ANNs
- simulate spiking neuronal networks
- read and understand the main ideas and methods presented in today’s neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

The course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control. This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools are used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

The course will be offered again in FS23.
Objective

This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to
- identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content

Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes

Lecture notes will be posted on Moodle.

Literature

Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas


Algorithms for Reinforcement Learning, Csaba Czepevzsi.


Prerequisites / notice

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5300-00L Guarantees for Machine Learning

W 7 credits 3V+1U+2A  F. Yang, A. Sanyal

Number of participants limited to 30.

Abstract

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/ “Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Tufted competencies

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

401-3055-64L Algebraic Methods in Combinatorics

W 6 credits 2V+1U  B. Sudakov

Does not take place this semester.

Abstract

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure $A$ one maps its elements to vectors in a linear space, and shows that the set $A$ is mapped to linearly independent vectors. It then follows that the cardinality of $A$ is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at [link].

> Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

> Students are expected to have a mathematical background and should be able to write rigorous proofs.

### 401-3621-00L

**Fundamentals of Mathematical Statistics**

W 10 credits 4V+1U  S. van de Geer

**Abstract**

The course covers the basics of inferential statistics.

**Content**

Key topics include:

- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Former course title: Mathematical Optimization.

### 401-3901-00L

**Linear & Combinatorial Optimization**

W 11 credits 4V+2U  R. Zenklusen

**Abstract**

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**

- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

### Electives

This is only a short selection. Other courses from the ETH course catalogue may be chosen in agreement with your tutor.

As an alternative to the elective courses, students may do a second semester project or an internship in industry. Please consult your tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>401-3054-14L</td>
<td>Probabilistic Methods in Combinatorics</td>
</tr>
</tbody>
</table>

**Abstract**

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

**Content**

The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

**Literature**

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:

1. Broaden understanding of management principles and frameworks
2. Advance insights into the sources of corporate and entrepreneurial success
3. Develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.
**Objective**
The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

**Content**
Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

Students have the option to either write this alone or in a group of two students.

**Literature**
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td></td>
<td>Problem-solving</td>
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<td>Critical Thinking</td>
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**363-0790-00L Technology Entrepreneurship**

**Abstract**
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

**Objective**
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.

A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

**Content**
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

**Lecture notes**
Lecture slides and case material

**363-1082-00L Enabling Entrepreneurship: From Science to Startup**

**Abstract**
This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

**Objective**
Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch

**Data:** 18.08.2022 12:39
**Autumn Semester 2022**
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The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and which are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders' agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes
Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Prerequisites / notice
This course is relevant for those students who aspire to become entrepreneurs. Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

851-0703-00L Introduction to Law
Students who have attended or will attend the lecture “Introduction to Law for Civil Engineering and Architecture” (851-0703-03L) or “Introduction to Law” (851-0708-00L), cannot register for this course unit.

Particularly suitable for students of D-ARCH, D-MAVT, D-MATL

Abstract
This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Objective
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

Content
Basic concepts of law, sources of law.
Private law: Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.

Insights into the law of the EU and into criminal law.

Lecture notes
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Literature
Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

851-0735-10L Law for Entrepreneurs
Number of participants limited to 100

Particularly suitable for students of D-ITET, D-MAVT

Abstract
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective
The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed
- They shall be able to contribute to the legal management of the company and to discuss legal issues
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes
A comprehensive script will be made available online on the moodle platform.

851-0738-00L Intellectual Property: Introduction
Particularly suitable for students of D-CHAB, D-INFK, D-ITET, D-MAVT, D-MATL, D-MTEC

Abstract
The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.
The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

### 851-0738-01L

**The Role of Intellectual Property in the Engineering and Technical Sector**

**Title:** The Role of Intellectual Property in the Engineering and Technical Sector  
**Type:**  
**ECTS:** 2  
**W:** 2

**K. Houshang Pour Islam**

**Abstract**

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

**Objective**

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

**Topics covered during the lecture will include:**
- The importance of innovation in industrialised countries  
- An overview of the different forms of intellectual property  
- The protection of technical inventions and how to safeguard their commercialisation  
- Patents as a source of technical and business information  
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

**Case studies will illustrate and deepen the topics addressed during the lecture.**

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

**Prerequisites / notice**

The lecture address students in the fields of engineering, science and other related technical fields.

### Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1550-10L</td>
<td>Internship in Industry, Only for Electrical Engineering and Information Technology MSc (Programme Regulations 2018).</td>
<td>W</td>
<td>12 credits</td>
<td>external organisers</td>
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</tr>
</tbody>
</table>

**Abstract**

The main objective of the 12-week internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

**Objective**

The main objective of the internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

### Master Studies (Programme Regulations 2008)

### Major Courses

### Communication

#### Core Subjects

* These core subjects are particularly recommended for the field of "Communication".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0301-00L</td>
<td>Optical Communication Fundamentals</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U+1P</td>
<td>J. Leuthold</td>
</tr>
</tbody>
</table>

**Abstract**

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

**Objective**

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

**Content**

* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection teqchniques, Error correction coding.
* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
* Chapter 7: Optical Amplifiers : Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.
227-0417-00L Information Theory I  W  6 credits  4G  A. Lapidoth

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content
The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Recommended Subjects
These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number  Title  Type  ECTS  Hours  Lecturers
227-0102-00L Discrete Event Systems  W  6 credits  4G  L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes
Available

Literature
[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv
Cambridge University Press, 1998

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser

227-0103-00L Control Systems  W  6 credits  2V+2U  F. Dörfler

Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.
Content

Literature

Prerequisites / notice
Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type of Course</th>
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</thead>
<tbody>
<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>6 credits</td>
<td>W</td>
</tr>
<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>6 credits</td>
<td>W</td>
</tr>
<tr>
<td>227-0301-00L</td>
<td>Optical Communication Fundamentals</td>
<td>6 credits</td>
<td>W</td>
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</tbody>
</table>

**Abstract**

227-0116-00L: This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

**Content**

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
  - Register Transfer Level (RTL) synthesis and its limitations.
  - Building blocks of digital VLSI circuits.
  - Functional verification techniques and their limitations.
  - Modular and largely reusable testbenches.
  - Assertion-based verification.
  - Synchronous versus asynchronous circuits.
  - The case for synchronous circuits.
  - Periodic events and the Anceau diagram.
  - Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

**Lecture notes**

Textbook and all further documents in English.

**Literature**


**Prerequisites / notice**

Prerequisites:
- Basics of digital circuits.
- Examination:
  - In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.
- Further details:
  - https://is-students.ee.ethz.ch/lectures/vlsi-i/

227-0166-00L: This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

**Content**

- Review of bipolar and MOS devices and their small-signal equivalent circuit models: Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.
- The exercise sessions aim to reinforce the lecture material by well-timed step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

**Lecture notes**

Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature**


227-0301-00L: The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

**Objective**

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired

Neural Network Theory


$2V+1U$

Course material: Script, computer demonstrations, exercises and problem solutions

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta

$3V+1U$

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep

The course language is English.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems

(including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Literature</th>
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</table>

Lecture notes are handed out.

Detailed lecture notes are available on the course web page

https://www.mins.ee.ethz.ch/teaching/intl/notice

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory

in particular.


* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.


Neural Network Theory

Does not take place this semester.

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation

Theorem, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired

a working knowledge of the mathematical foundations of neural networks.

1. Universal approximation with single- and multi-layer networks

2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal

   classes, non-linear approximation theory

3. Fundamental limits of deep neural network learning

4. Geometry of decision surfaces

5. Separating capacity of nonlinear decision surfaces

6. Vapnik-Chervonenkis (VC) dimension

7. VC dimension of neural networks

8. Generalization error in neural network learning

Lecture notes are available on the course web page

https://www.mins.ee.ethz.ch/teaching/intl/notice

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory

in particular.

Image Analysis and Computer Vision


Image segmentation. Motion extraction and tracking. 3D data extraction. Invariant features. Specific object recognition and object class


Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience

through practical computer and programming exercises.

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep

learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image

processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is

considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then
turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear

filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic

information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific

objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based

approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets

are given.

Course material: Script, computer demonstrations, exercises and problem solutions

Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

Analog Signal Processing and Filtering

Suitable for Master Students as well as Doctoral Students.

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta

conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow

view. The lecture is suitable for both analog and digital designers.

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta

conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow

view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two

groups.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems

(including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.
At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

Details: [https://people.ee.ethz.ch/~haschmid/asfwiki/](https://people.ee.ethz.ch/~haschmid/asfwiki/)

The graph methods are also supported with teaching videos: [https://tube.switch.ch/channels/d206c96c?order=episodes](https://tube.switch.switch.ch/channels/d206c96c?order=episodes), and a Python-based open-source tool to manipulate graphs is available on [https://github.com/hanspi42/signalflowgrapher](https://github.com/hanspi42/signalflowgrapher)

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites / notice

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

### Taught competencies

#### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

#### Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

#### Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### 227-0477-00L Acoustics I

#### Abstract

Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.

#### Objective

Understanding the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments. Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

#### Content

Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.

#### Lecture notes

Yes

#### Taught competencies

- Subject-specific Competencies: Concepts and Theories: assessed
- Method-specific Competencies: Analytical Competencies: assessed
- Social Competencies: Communication: assessed
- Personal Competencies: Creative Thinking: assessed

### 252-0535-00L Advanced Machine Learning

#### Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

#### Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-4640-00L  Network Security  W 8 credits  2V+2U+3A  A. Perrig, S. Frei, M. Legner, K. Paterson

Abstract
Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
(3) analysis and inference topics such as traffic monitoring and network forensics; and
(4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
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<td>Customer Orientation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
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</tbody>
</table>

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401-3055-64L  Algebraic Methods in Combinatorics  W  6 credits  2V+1U  B. Sudakov

Abstract
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice
Students are expected to have a mathematical background and should be able to write rigorous proofs.


Abstract
This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

Objective
At the end of this course, you will
- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

Content
The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

Literature
N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

Prerequisites / notice
VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

Taught competencies
Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed, Problem-solving assessed

Computers and Networks

Core Subjects
These core subjects are particularly recommended for the field of “Computers and Networks”.

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Content
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

Lecture notes
All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

The video recordings of the lectures are expected to be made available after lectures.

We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

We provide relevant references will be made available through the course website.

Prerequisites / notice

227-0575-00L Advanced Topics in Communication Networks W 6 credits 2V+2U L. Vanbever, R. Jacob

Abstract
This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover advanced topics in Internet routing and forwarding.

Objective
The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.

Content
The course will cover advanced topics in Internet routing and forwarding such as:
- Tunneling
- Hierarchical routing
- Traffic Engineering and Load Balancing
- Virtual Private Networks
- Quality of Service/Queuing/Scheduling
- Fast Convergence
- Network virtualization
- Network programmability (OpenFlow, P4)
- Network measurements

Lecture notes
Lecture notes and material will be made available before each course on the course website.

Literature
Lecture notes and material will be made available through the course website.

Prerequisites / notice
Prerequisites: Communication Networks (227-0120-00L) or equivalents / good programming skills (in any language) are expected as both the exercises and the final project will involve coding.

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking

227-0579-00L Hardware Security W 7 credits 2V+2U+2A K. Razavi

Abstract
This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.

Objective
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:
- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.
- writing critical reviews and constructive discussions with peers on this topic.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Slides, relevant literature and manuals will be made available during the course.

Literature
Experience with Linux, systems programming and computer architecture.

252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde

Abstract
The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.
The first part of the lecture covers individual system's aspects starting with tamperproof or tamperresistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TGG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-4640-00L  Network Security

4G

W 8 credits

2V+2U+3A

A. Perrig, S. Frei, M. Legner, K. Paterson

Abstract

Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content

The course will cover topics spanning four broad themes with a focus on the first two themes:

1. network defense mechanisms such as public-key infrastructures, TLS, VPsns, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Taught competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Recommended Subjects

These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number Title Type ECTS Hours Lecturers

227-0101-00L Discrete-Time and Statistical Signal Processing W 6 credits 4G H.-A. Loeliger

Abstract

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability, in the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content

1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

Lecture Notes
### 227-0103-00L Control Systems

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<th>6 credits</th>
<th>2V+2U</th>
<th>F. Dörfler</th>
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<td>Abstract</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Signal and Systems Theory II.</td>
<td>MATLAB is used for system analysis and simulation.</td>
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### 227-0116-00L VLSI 1: HDL Based Design for FPGAs

<table>
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<th>VLSI 1: HDL Based Design for FPGAs</th>
<th>W</th>
<th>6 credits</th>
<th>5G</th>
<th>F. K. Gürkaynak, L. Benini</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.</td>
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<tr>
<td>Objective</td>
<td>Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Array (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conceptions to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.</td>
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<tr>
<td>Content</td>
<td>This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:</td>
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<td></td>
<td>- Overview on design methodologies and fabrication depths.</td>
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<td></td>
<td>- Levels of abstraction for circuit modeling.</td>
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<td></td>
<td>- Organization and configuration of commercial field-programmable components.</td>
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<td></td>
<td>- FPGA design flows.</td>
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<td></td>
<td>- Dedicated and general purpose architectures compared.</td>
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<td></td>
<td>- How to obtain an architecture for a given processing algorithm.</td>
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<td>- Meeting throughput, area, and power goals by way of architectural transformations.</td>
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<td></td>
<td>- Hardware Description Languages (HDL) and the underlying concepts.</td>
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<td>- SystemVerilog</td>
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<td>- Register Transfer Level (RTL) synthesis and its limitations.</td>
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<td>- Building blocks of digital VLSI circuits.</td>
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<td>- Functional verification techniques and their limitations.</td>
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<td></td>
<td>- Modular and largely reusable testbenches.</td>
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<td>- Assertion-based verification.</td>
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<td>- Synchronous versus asynchronous circuits.</td>
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<td>- The case for synchronous circuits.</td>
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<td>- Periodic events and the Anceau diagram.</td>
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<td></td>
<td>- Case studies,ASICs compared to microprocessors, DSPs, and FPGAs.</td>
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<tr>
<td>Literature</td>
<td>Textbook and all further documents in English.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basics of digital circuits.</td>
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<td>Notice</td>
<td>Examination:</td>
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<td></td>
<td>In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.</td>
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<tr>
<td>Further details</td>
<td><a href="https://isis.students.ee.ethz.ch/lectures/vlsi-i/">https://isis.students.ee.ethz.ch/lectures/vlsi-i/</a></td>
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</table>

### 227-0377-10L Physics of Failure and Reliability of Electronic Devices and Systems

<table>
<thead>
<tr>
<th>Physics of Failure and Reliability of Electronic Devices and Systems</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>I. Shorubalko, M. Held</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.</td>
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<tr>
<td>Objective</td>
<td>Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.</td>
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<tr>
<td>Content</td>
<td>Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).</td>
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<tr>
<td>Lecture notes</td>
<td>Comprehensive copy of transparencies</td>
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</table>

### 227-0447-00L Image Analysis and Computer Vision

<table>
<thead>
<tr>
<th>Image Analysis and Computer Vision</th>
<th>W</th>
<th>6 credits</th>
<th>3V+1U</th>
<th>E. Konukoglu, F. Yu</th>
</tr>
</thead>
</table>
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate
Computer Architecture
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a
Embedded Control Systems
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep
Learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image
processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is
considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then
turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear
filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic
information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific
objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based
approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are
given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
The course language is English.

227-0555-00L Distributed Systems W 4 credits 3G+1A R. Wattenhofer

Enrolled students will be notified by e-mail about the lecture start.

Abstract
This course introduces the fundamentals of distributed systems. We study different protocols and algorithms that allow for fault-tolerant
operation, and discuss practical systems that implement these techniques.

Objective
The objective of the course is for students to understand the theoretical principles and practical considerations of distributed systems. This
includes the main models of fault-tolerant distributed systems (crash failures, byzantine failures, and selfishness), and the most important
algorithms, protocols and impossibility results. By the end of the course, students should be able to reason about various concepts such as
consistency, durability, availability, fault tolerance, and replication.

Content
We discuss the following concepts related to fault-tolerant distributed systems: client-server, serialization, two-phase protocols, three-phase
protocols, Paxos, two generals problem, crash failures, impossibility of consensus, byzantine failures, agreement, termination, validity,
byzantine agreement, ring algorithm, asynchronous byzantine agreement, authentication, signatures, reliable and atomic broadcast,
existent consensus, blockchain, proof-of-work, proof-of-, smart contracts, quantum systems, fault-tolerant protocols such as pChain or pbft, distributed storage, distributed hash tables, physical and logical clocks, causality,
selfishness, game theoretic models, mechanism design.

Lecture notes
A script is available on the web page.

Literature
The script is self-contained, but links to additional material are available on the web page.

Prerequisites / notice
This lecture takes place in roughly the second half of the semester, as the lecture is the second part of the lecture "Computer Systems"
(252-0217-00). Students may attend at most one of the two lectures, 6G+1A both.

227-2210-00L Computer Architecture W 8 credits 6G+1A O. Mutlu

Abstract
Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a
computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective
We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in
Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory
controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research.

Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate
simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction,
prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth
understanding of specific system components (e.g., memory scheduling, prefetching).

Lecture notes
See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

The video recordings of the lectures are expected to be made available after lectures.

Literature
See https://safari.ethz.ch/architecture for past examples.

We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major
Computer Architecture and related conferences and journals.

Prerequisites / notice

151-0593-00L Embedded Control Systems W 4 credits 6G C. Onder, M. Schmid Daners

Abstract
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a
microprocessor-controlled haptic device.

Objective
Familiarizes students with major architectural principles and concepts of embedded control systems.

Content
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this
intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an
example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping
This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischnm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website

http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

<table>
<thead>
<tr>
<th>252-1411-00L</th>
<th>Security of Wireless Networks</th>
<th>W</th>
<th>6 credits</th>
<th>2V+2U+2A</th>
<th>S. Capkun, K. Kostiainen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques</td>
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<tr>
<td><strong>Objective</strong></td>
<td>After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.</td>
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<tr>
<th>401-3055-64L</th>
<th>Algebraic Methods in Combinatorics</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>B. Sudakov</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.</td>
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<tr>
<td><strong>notice</strong></td>
<td>One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to a set B in a linear space which is much smaller. This idea is surprisingly powerful and has many famous applications.</td>
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<tr>
<td><strong>notice</strong></td>
<td>This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):</td>
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<tr>
<td><strong>notice</strong></td>
<td>Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.</td>
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<tr>
<td><strong>Lecturenotes</strong></td>
<td>The course website can be found at <a href="https://moodle-app21.ethz.ch/course/view.php?id=15757">https://moodle-app21.ethz.ch/course/view.php?id=15757</a></td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Students are expected to have a mathematical background and should be able to write rigorous proofs.</td>
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Electronics and Photonics

Core Subjects

These core subjects are particularly recommended for the field of “Electronics and Photonics”.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0146-00L</td>
<td>Analog-to-Digital Converters</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>T. Burger</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. The student will learn to understand the basic principles behind data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained with their principle of operation accompanied with the appropriate mathematical calculations, including the non-idealities in some cases. After successful completion of the course the student should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.</td>
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<tr>
<td><strong>Content</strong></td>
<td>- Introduction: information representation and communication; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.</td>
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<td><strong>notice</strong></td>
<td>- Dual-slope &amp; successive approximation register (SAR) converters: dual-slope principle &amp; converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.</td>
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<td><strong>notice</strong></td>
<td>- Algorithmic &amp; pipelined A/D converters: algorithmic conversion principle; sample &amp; hold stage; pipe-lined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.</td>
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<tr>
<td><strong>notice</strong></td>
<td>- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.</td>
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<tr>
<td><strong>notice</strong></td>
<td>- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkles correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters.</td>
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<td><strong>notice</strong></td>
<td>- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.</td>
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<tr>
<td><strong>notice</strong></td>
<td>- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-oder delta-sigma modulation, circuit level implementation; clock-jitter &amp; SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.</td>
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<tr>
<td><strong>notice</strong></td>
<td>Digital-to-analog converters: introduction; current scaling D/A converter, current steering DAC, calibration for improved performance.</td>
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<tr>
<td><strong>Lecturenotes</strong></td>
<td>Slides are available online under <a href="https://lis-students.ee.ethz.ch/lectures/analog-to-digital-converters/">https://lis-students.ee.ethz.ch/lectures/analog-to-digital-converters/</a></td>
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</table>
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives assessed


VLSI 3: Full-Custom Digital Circuit Design

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

At the end of this course, you will

• understand the design of the main building blocks of state-of-the-art digital integrated circuits
• be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
• be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
• understand the performance trade-offs between delay, area, and power consumption

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

• Nanometer MOSFETs
• Static and dynamic behavior of complementary MOS (CMOS) inverters
• CMOS gate design, sizing, and timing
• Full-custom standard-cell design
• Wire models and parasitics
• Latch and flip-flop circuits
• Gate-level timing analysis and optimization
• Static and dynamic power consumption; low-power techniques
• Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
• Arithmetic and logic circuits
• Fixed-point and floating-point arithmetic
• Synchronous and asynchronous design principles
• Memory circuits (ROM, SRAM, and DRAM)
• In- and near-memory processing architectures
• Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Problem-solving

Optical Communication Fundamentals

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.


* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

* Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes are handed out.

Literature

Govind P. Agrawal; "Fiber-Optic Communication Systems”; Wiley, 2010


This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.
Lecturers

T. Delbrück
- Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, Nonlinear Optics

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on second harmonic generation, four-wave mixing or soliton propagation and others.

ECTS

The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematically by means of the susceptibility.

J. Leuthold
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics

Nanodynamics

Chapter 2: Nonlinear Effects - An Overview
Chapter 3: The Nonlinear Optical Susceptibility
Chapter 4: Second Harmonic Generation
Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator
Chapter 6: Acousto-Optic Effect
Chapter 7: Nonlinear Effects - Third Order
Chapter 8: Nonlinear Effects in Media with Gain

Literature

Lecture notes are distributed. For students enrolled in the course, additional information, lecture notes and exercises can be found on moodle (https://moodle-app2.let.ethz.ch/).

Prerequisites / notice

- Electromagnetic fields and waves (or equivalent)
- Physics I+II

Neuromorphic Engineering I

Registration in this course requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH. Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course 'Neuromorphic Engineering II', that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Recommended Subjects

These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number Title Type ECTS Hours Lecturers
227-0663-00L Nano-Optics W 6 credits 2V+2U M. Frimmer
Abstract Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, photonic crystals, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Objective Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

Content We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

Prerequisites / notice

- Electromagnetic fields and waves (or equivalent)
- Physics I+II

227-0565-00L Nonlinear Optics W 6 credits 2V+2U J. Leuthold
Abstract Nonlinear Optics deals with the interaction of light with material, the response of material to light and the mathematical framework to describe the phenomena. As an example we will cover fundamental phenomena such as the refractive index, the electro-optic effect, the nonlinear optical susceptibility.

Objective The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematically by means of the susceptibility.

Content Chapter 1: The Wave Equations in Nonlinear Optics
Chapter 2: Nonlinear Effects - An Overview
Chapter 3: The Nonlinear Optical Susceptibility
Chapter 4: Second Harmonic Generation
Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator
Chapter 6: Acousto-Optic Effect
Chapter 7: Nonlinear Effects - Third Order
Chapter 8: Nonlinear Effects in Media with Gain

Literature Lecture notes are distributed. For students enrolled in the course, additional information, lecture notes and exercises can be found on moodle (https://moodle-app2.let.ethz.ch/).

Prerequisites / notice

Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics

227-1033-00L Neuroemorphic Engineering I W 6 credits 2V+3U T. Delbrück, G. Indiveri, S.-C. Liu
Abstract This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective Understanding of the characteristics of neuromorphic circuit elements.

Content Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Recommended Subjects

These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number Title Type ECTS Hours Lecturers
227-0121-00L Communication Systems W 6 credits 4G to be announced
Abstract Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 936 of 2345
Objective
Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

Content
Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

Lecture notes
The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Literature

3. M. Bossert und M. Breitbach, Digitale Netze, 1. Auflage, Teubner, 1999

227-0155-00L Machine Learning on Microcontrollers

Abstract
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

Objective
Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras,..). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

Content
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercises will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Lecture notes
Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Prerequisites / notice
Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

227-0157-00L Semiconductor Devices: Physical Bases and Simulation

Abstract
The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

Objective
The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

Content
The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions. The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

Lecture notes
The script (in book style) can be downloaded from: https://is-students.ee.ethz.ch/lectures/

Prerequisites / notice

227-0166-00L Analog Integrated Circuits

Abstract
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems. The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Objective
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors. The exercise sessions aim to reinforce the lecture material well by guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes
Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature
Physics of Failure and Reliability of Electronic Devices and Systems

Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Comprehensive copy of transparencies


227-0468-00L Analog Signal Processing and Filtering

Suitable for Master Students as well as Doctoral Students.

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

This learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Cm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture “227-0166-00L Analog Integrated Circuits” complements this lecture very well in that respect.

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/
The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes , and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites: Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Simulation of Photovoltaic Devices - From Materials to Modules

The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules and large scale photovoltaic systems.

Get an overview over the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to predict the performance of solar cells and modules.
### Content
Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modeling for PV systems; Quantum simulation of nanostructure solar cell devices (bonus lecture)

### Literature

### Prerequisites / notice
Undergraduate physics, mathematics, semiconductor devices

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<th>Method-specific Competencies</th>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<tbody>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<tr>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-direction and Self-management</td>
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### 227-0617-00L Solar Cells

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<th>Credit(s)</th>
<th>Type</th>
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<tbody>
<tr>
<td>W 4 credits</td>
<td>3G</td>
<td>A. N. Tiwari, R. Carron, Y. Romanyuk</td>
</tr>
</tbody>
</table>

#### Objective
Introduction to solar radiation, physics, technology, characteristics and applications of photovoltaic solar cells and systems.

#### Content
Solar radiation characteristics, physical mechanisms for the light to electrical power conversion, properties of semiconductors for solar cells, processing and properties of conventional Si and GaAs based solar cells, technology and physics of thin film solar cells based on compound semiconductors, other solar cells including organic and dye sensitized cells, problems and new developments for power generation in space, interconnection of cells and solar module design, measurement techniques, system design of photovoltaic plants, system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples.

#### Lecture notes
Lecture reprints (in english).

#### Prerequisites / notice
Prerequisites: Basic knowledge of semiconductor properties.

### 227-0618-00L Modeling, Characterization and Reliability of Power Semiconductors

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<th>Credit(s)</th>
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<tr>
<td>W 6 credits</td>
<td>4G</td>
<td>M. P. M. Ciappa</td>
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</table>

#### Objective
This lecture provides theoretical and experimental knowledge on the techniques for the characterization and numerical modeling of power semiconductors, as well as on the related built-in reliability strategies.

#### Content
The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.

#### Literature
- Eiichi Ohno: "Introduction to Power Electronics"
- B. Murari et al.: "Smart Power ICs"
- B. J. Baliga: "Physics Modern Power Devices"
- S. K. Ghani: "Semiconductor Power Devices"

### 227-0619-00L Charge Transport in Energy Conversion and Storage Devices

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<th>Credit(s)</th>
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<tr>
<td>W 6 credits</td>
<td>2V+2U</td>
<td>C. Battaglia, A. Senocrate</td>
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</table>

#### Abstract
The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolyzers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.
By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolyser, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

**Literature**
- R. Huggins, Advanced Batteries, DOI:10.1007/9780387764245

**Prerequisites / notice**
Be motivated to change the world to renewable energies! Elements of calculus will be reviewed at the beginning of the course, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite. Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students. A visit to a solar cell or battery fab will be organized during the semester if the epidemiological situation permits.

**227-0653-00L Electromagnetic Precision Measurements and Optoelectronic Devices**

**Objective**
No credit. 4 credits 2V+1U M. Frimmer

**Abstract**
The course provides the basic knowledge necessary to understand current state-of-the-art optomechanical measurement systems operating at the precision limits set by the laws of quantum mechanics.

**Objective**
The goal of this course is to understand the fundamental limitations of measurement systems relying on electromagnetic fields.

**Content**
The course starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics.

**Prerequisites / notice**
1. Electrodynamics
2. Physics 1,2
3. Introduction to quantum mechanics

**227-0659-00L Integrated Systems Seminar**

**Objective**
The seminar aims at instructing graduate and PhD students in the basics of presentation techniques, i.e. "how to give a professional talk". Attendees have the possibility to become acquainted with a current topic by a literature study, and to present the results thereof in a 20 minutes talk in English. The participation at the seminar gives also an overview on current problems in modern nano- and opto-electronics.

**Content**
The seminar topics' are simulation of nanoelectronic processes and devices, and the optical as well as electronic simulation of optoelectronic devices as lasers, photodiodes, etc.

**Lecture notes**
Presentation material

**227-0665-00L Battery Integration Engineering**

**Objective**
No credit. 3 credits 2V+1U M. Luisier

**Abstract**
Batteries enable sustainable mobility, renewable power integration, various power grid services, and residential energy storage. Linked with low cost PV, Li-ion batteries are positioned to shift the 19th-century centralized power grid into a 21st-century distributed one. As with battery integration, this course combines understanding of electrochemistry, heat & mass transfer, device engineering.

**Objective**
The learning objectives are:
- Apply critical thinking on advancements in battery integration engineering. Assessment reflects this objective and is based on review of a scientific paper, with mark weighting of 10 / 25 / 65 for a proposal / oral presentation / final report, respectively.
- Design battery system concepts for various applications in the modern power system and sustainable mobility, with a deep focus on replacing diesel buses with electric buses combined with charging infrastructure.
- Critically assess progresses in battery integration engineering: from material science of novel battery technologies to battery system design.
- Apply "lessons learned" from the history of batteries to assess progress in battery technology.
- Apply experimental and physical concepts to develop battery models in order to predict lifetime.
- Battery systems for the modern power grid and sustainable mobility.
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy stroage.
- Sustainability and life cycle analysis of battery system innovations.

**Prerequisites / notice**
Priority given to Electrical and Mechanical Engineering students

**Literature**
- 227-0664-00L Technology and Policy of Electrical Energy Storage
- 529-0440-00L Physical Electrochemistry and Electrocatalysis
- 529-0191-00L Renewable Energy Technologies II, Energy Storage and Conversion
- 227-0659-00L Electrochemistry (Exception for PhD students)

**Notice**
Does not take place this semester.
### 227-2037-00L Physical Modelling and Simulation

<table>
<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>J. Smajic</th>
</tr>
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</table>

#### Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

#### Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are attained.

#### Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

### 151-0601-00L Theory of Robotics and Mechatronics

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<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>to be announced</th>
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#### Abstract
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

#### Objective
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

#### Content
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

#### Lecture notes
available.

### 151-0605-00L Nanosystems

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<th>W</th>
<th>4 credits</th>
<th>4G</th>
<th>A. Stemmer</th>
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#### Abstract
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.

Special emphasis is placed on the emerging field of molecular electronic devices.

#### Objective
Familiarize students with basic science and engineering principles governing the nano domain.

The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

#### Literature

#### Prerequisites / notice
Lectures and Mini-Review presentations: Thursday 10-13

Homework: Mini-Review
(compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

### 151-0620-00L Embedded MEMS Lab

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<tr>
<th>W</th>
<th>5 credits</th>
<th>3P</th>
<th>C. Hierold, M. Haluska</th>
</tr>
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</table>

Mandatory - background knowledge in batteries & electrochemistry acquired in one of the following courses:
- 227-0604-00L Technology and Policy of Electrical Energy Storage
- 259-0940-00L Physical Electrochemistry and Electroanalysis
- 259-0911-01L Renewable Energy Technologies II, Energy Storage and Conversion
- 259-0659-00L Electrochemistry

Exception given for PhD students
The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

The course is offered in autumn and spring semester.

### 327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation

- **Objective**: Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

- **Content**: With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
  - Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
  - Packaging and electrical connection of a MEMS device
  - Testing and characterization of the MEMS device
  - Written documentation and evaluation of the entire production, processing and characterization

- **Prerequisites / notice**: Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course. For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:
  - **Priority 1**: master's program in “Micro and Nanosystems”
  - **Priority 2**: master's program in “Mechanical Engineering” with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Prof. Dario, Dual, Hierold, Koumoutsakos, Nelson, Rousis, Poulikakos, Pratsinis, Stemmner), who attended the bachelor course “151-0621-00L Microsystems Technology” successfully.
  - **Priority 3**: master students, who attended the bachelor course “151-0621-00L Microsystems Technology” successfully.
  - **Priority 4**: all other students (PhD, bachelor, master) with a background in silicon or Microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

- **Notice**: The course does not take place this semester.

### 363-0389-00L Technology and Innovation Management

- **Objective**: The course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

- **Content**: Types of decision-making criteria and their importance; the role of technology management; the role of innovation management.

- **Prerequisites / notice**: The course content and methods are designed for students with some background in management and/or economics.

### 401-3055-64L Algebraic Methods in Combinatorics

**Abstract**: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access.

**Objective**: Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

**Content**: With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:

- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

**Lecture notes**: A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

**Literature**: The document provides sufficient information for the participants to successfully participate in the course.

**Prerequisites / notice**: Participating students are required to attend all scheduled lectures and meetings of the course.

- **Notice**: The course does not take place this semester.

**Data**: 18.08.2022 12:39  
**Autumn Semester 2022**  
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### Combinatorics

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

**Content**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure $A$ one maps its elements to vectors in a linear space, and shows that the set $A$ is mapped to linearly independent vectors. It then follows that the cardinality of $A$ is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments.
- Spaces of polynomials and tensor product methods.
- Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem.
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at [https://moodle-app2.let.ethz.ch/course/view.php?id=15757](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)

### Energy and Power Electronics

#### Core Subjects

These core subjects are particularly recommended for the field of "Energy and Power Electronics".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0117-00L</td>
<td>High Voltage Engineering</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>C. Franck, U. Straumann</td>
</tr>
</tbody>
</table>

#### Abstract
High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, ... High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages.

#### Objective
The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

- Discussion of the field equations relevant for high voltage engineering.
- Analytical and numerical solutions/solving of these equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations.
- Introduction to kinetic gas theory.
- Mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems.
- Methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations.
- Application of the expertise on high voltage components.
- Excursions to manufacturers of high voltage components.

### Literature

### Taught competencies

<table>
<thead>
<tr>
<th>Subject</th>
<th>Competencies</th>
<th>Type</th>
<th>Taught competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Assessed</td>
<td></td>
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<tr>
<td>Techniques and Technologies</td>
<td>Assessed</td>
<td></td>
<td></td>
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<tr>
<td>Analytical Competencies</td>
<td>Not Assessed</td>
<td></td>
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</tr>
<tr>
<td>Decision-making</td>
<td>Not Assessed</td>
<td></td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Not Assessed</td>
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<tr>
<td>Problem-solving</td>
<td>Not Assessed</td>
<td></td>
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<tr>
<td>Project Management</td>
<td>Not Assessed</td>
<td></td>
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<tr>
<td>Communication</td>
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<td></td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>Not Assessed</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>Not Assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>Not Assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>Not Assessed</td>
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<tr>
<td>Negotiation</td>
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<tr>
<td>Adaptability and Flexibility</td>
<td>Not Assessed</td>
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<tr>
<td>Creative Thinking</td>
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<tr>
<td>Critical Thinking</td>
<td>Not Assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>Not Assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>Not Assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>Not Assessed</td>
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</table>
Objective
Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero
voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter
systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and
inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion
of three-phase PWM converters systems in the lecture Power Electronic Systems II.

Content
Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching
losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the
operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency
loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the
concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of
three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components
based on analytical calculations is explained.

Lecture notes
Lecture notes and associated exercises including correct answers.

Prerequisites / notice
Prerequisites: Introductory course on power electronics is recommended.

227-0526-00L Power System Analysis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0526-00L</td>
<td>Power System Analysis</td>
<td>W</td>
<td>6 credits</td>
<td>G. Hug</td>
</tr>
</tbody>
</table>

Objectives
The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the
development of stationary models of the electrical network, their mathematical representation and special characteristics and solution
methods of large linear and non-linear systems of equations related to electrical power networks.

Lecture notes
Lecture notes.

4G

Power System Analysis

The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis
tools in steady and dynamic states.

Content
The course includes the development of stationary models of the electrical network, their mathematical representation and special
characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such
as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion
and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes
Lecture notes.

Recommended Subjects
These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number | Title | Type | ECTS | Hours |
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

Objective
The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-
time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation
theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Content
1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.
2. The discrete Fourier transform and its use for digital filtering.
   - The statistical perspective: probability, random variables, discrete-time stochastic processes;
   - detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
   - Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes
Lecture Notes.

227-0121-00L Communication Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0121-00L</td>
<td>Communication Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
</tr>
</tbody>
</table>

Objectives
Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer,
MAC, Example Layer 2, Layer 3, Internet

Content
Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of
information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed
elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of
perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing
and flow control will be treated.

Lecture notes
Lecture Slides

Literature

227-0225-00L Linear System Theory

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
</tr>
</tbody>
</table>

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes
Available on the course Moodle platform.
### Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Taught competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Creative Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### 227-0517-10L Fundamentals of Electric Machines

| Abstract | This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed. |
| Objective | The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts. |
| Content | - Fundamentals in magnetic circuits and electromechanical energy conversion.  
- Force and torque calculation.  
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).  
- Complex space vector notation, rotating coordinate system (dq-transformation).  
- Loss components in electric machines, scaling laws of electromechanical actuators.  
- Mechanical and thermal modelling. |
| Lecture notes | Lecture notes and associated exercises including correct answers |

### 227-0523-00L Railway Systems I

| Abstract | Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:  
- Transportation tasks and vehicle types  
- Running dynamics  
- Mechanical part of rail vehicles  
- Brakes  
- Traction chain and auxiliary supply  
- Railway power supply  
- Signalling systems  
- Standards  
- Availability and safety  
- Traffic control and maintenance |
| Objective | - Overview of the technical characteristics of railway systems  
- Know-how about the design and construction principles of rail vehicles  
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)  
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries  
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland  
- Motivation of young engineers to start a career in the railway industry or with railway operators |
| Content | EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale  
1 Einführung:  
1.1 Geschichte und Struktur des Bahnsystems  
1.2 Fahrdynamik  
2 Vollbahnhilfsleistung:  
2.1 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion  
2.2 Bremse  
2.3 Traktionsanschwerpunkte  
2.4 Hilfsbetriebe und Komfortanlagen  
2.5 Steuerung und Regelung  
3 Infrastruktur:  
3.1 Fahrweg  
3.2 Bahnstromversorgung  
3.3 Sicherungssysteme  
4 Betrieb:  
4.1 Interoperabilität, Normen und Zulassung  
4.2 RAMS, LLC  
4.3 Anwendungsbeispiele  
Voraussichtlich ein oder zwei Gastreferate  
Geplante Exkursionen:  
Betriebszentrale SBB, Zürich Flughafen  
Reparatur und Unterhalt, SBB Zürich Altstetten  
Fahrzeugfertigung, Stadler Bussnang |
| Lecture notes | Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen. |
Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>Dozent: Dr. Markus Meyer, Emkamatik GmbH</th>
</tr>
</thead>
</table>

227-0536-00L Multiphysics Simulations for Power Systems

This course is defined so and planned to be an addition to the module "227-0537-00L Technology of Electric Power System Components". However, the students who are familiar with the fundamentals of electromagnetic fields could attend only this course without its 227-0537-00-complement.

Abstract

The goals of this course are a) understanding the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations and b) performing effective simulations of primary equipment of electric power systems. The course is understood complementary to 227-0537-00L "Technology of Electric Power System Components", but can also be taken separately.

Objective

The student should learn the fundamentals of the electromagnetic, thermal, mechanical, and coupled fields simulations necessary for modern product development and research based on virtual prototyping. She / he should also learn the theoretical background of the finite element method (FEM) and its application to low- and high-frequency electromagnetic field simulation problems. The practical exercises of the course should be done by using one of the commercially available field simulation software (Infolytica, ANSYS, and / or COMSOL). After completing the course the student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.

Content

1. Electromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
   a. Short review of the governing equations
   b. Boundary conditions
   c. Initial conditions
   d. Linear and nonlinear material properties
   e. Coupled fields (electromechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgear (GIS)
   f. Electromagnetic compatibility (EMC)

227-0567-00L Design of Power Electronic Systems

Abstract

Complete design process: from given specifications to a complete power electronic system; selection / design of suitable passive power components; static and dynamic properties of power semiconductors; optimized EMI filter design; heat sink optimization; additional circuitry, e.g. gate driver; system optimization.

Objective

Basic knowledge of design and optimization of a power electronic system; furthermore, lecture and exercises thoroughly discuss key subjects of power electronics that are important with respect to a practical realization, e.g. how to select suitable power components, to understand switching operations, calculation of high frequency losses, EMI filter design and realization, thermal considerations.

Content

Complete design process: from given specifications to a complete power electronic system.

Selection and / or design of suitable passive power components: specific properties, parasitic components, tolerances, high frequency losses, thermal considerations, reliability.

Static and dynamic characteristics of power semiconductors.

Optimized design of the EMI filter.

Thermal characterization of the converter, optimized heat sink design.

Additional circuitry: gate driver, measurement, control.

Converter start up: typical sequence of events, circuitry required.

Overall system optimization: identifying couplings between different components of the considered power electronic system, optimization targets and issues.

Lecture notes

Lecture notes and complementary exercises including correct answers.

Prerequisites / notice

Prerequisites: Introductory course on power electronics.

227-0618-00L Modeling, Characterization and Reliability of Power Semiconductors

Abstract

This lecture provides theoretical and experimental knowledge on the techniques for the characterization and numerical modeling of power semiconductor devices, as well on the related built-in reliability strategies.

Objective

The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.
This lecture consists of a theoretical part (50%) and of laboratory exercises and demonstrations (50%). The theoretical part covers the basic techniques and procedures for characterization, modeling and built-in reliability of modern power semiconductor devices with special attention to MOS and IGBT. The starting part on technology provides an overview on the main device families and includes a review of the most relevant application-oriented aspects of the device physics, thermal management, and packaging. The second section deals with the basic experimental characterization techniques for the definition of the semiconductor material properties, electrical characteristics, safe operating area, and junction temperature of the devices. The following section introduces the basic principles for electrical, thermal, and electro-thermal simulation of power semiconductors by Technology Computed Aided Design (TCAD) and compact modeling. Finally, procedures are methods are presented to implement efficient built-in reliability programs targeted on power semiconductors. They include failure physics, dedicated failure analysis techniques, accelerated testing, defect screening, and lifetime modeling.

During the laboratory activities, selections of the experimental techniques presented in the lecture are demonstrated on the base of realistic examples. Furthermore, schematic power devices will be simulated by the students with advanced TCAD tools and circuit simulators.

**Lecture notes**
Handouts to the lecture (approx. 250 pp.)

**Literature**
Eichi Ohno: "Introduction to Power Electronics"
B. Murari et al.: "Smart Power ICs"
B. J. Baliga: "Physics Modern Power Devices"
S. K. Ghandi: "Semiconductor Power Devices"

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**227-0697-00L Industrial Process Control**

**W 4 credits 3G**
A. Horch, L. Dominguez Palomeque

**Abstract**
Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing.

**Objective**
General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends.

**Content**
- Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries.
- Analysis and design of open loop control problems: discrete automatia, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.
- Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text);
- PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.
- Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.

**Lecture notes**
Slides will be available as .PDF documents, see "Learning materials" (for registered students only)

**Prerequisites / notice**
References will be given at the end of individual lectures.
Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

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**227-0731-00L Power Market I - Portfolio and Risk Management**

**W 6 credits 4G**
D. Reichelt, G. A. Koeppep

**Abstract**
Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

**Objective**

**Content**
1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX
2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions
3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)
4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

**Lecture notes**
Handouts of the lecture

**Prerequisites / notice**
1 excursion per semester, 2 case studies, guest speakers for specific topics.
Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636
Discrete Event Systems
ECTS
W 2V+1U 5G

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the development of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, which is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective; we model discrete events in stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number Title Type ECTS Hours Lecturers
227-0225-00L Linear System Theory W 6 credits 5G J. Lygeros, A. Tsiamis
Abstract

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in construction of proofs of properties of linear control systems.

Objective

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes

Available on the course Moodle platform.

Prerequisites / notice

Sufficient mathematical maturity, in particular in linear algebra, analysis.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed

Personal Competencies

Creative Thinking not assessed
Critical Thinking not assessed
Integrity and Work Ethics not assessed

227-0697-00L Industrial Process Control W 4 credits 3G A. Horch, L. Dominguez Palomeque
Abstract

Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, which is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

Objective

General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends.

Content

- Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering.
- Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.
- Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text); PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.
- Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.

Lecture notes

Slides will be available as .PDF documents, see "Learning materials" (for registered students only)

Literature

References will be given at the end of individual lectures.

Prerequisites / notice

Exercises: Tuesday 15-16

Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea
Abstract

Introduction to Dynamic Programming and Optimal Control.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

- Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.
- Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Lecture notes

Available

Number Title Type ECTS Hours Lecturers
227-0102-00L Discrete Event Systems W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer
Abstract

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective

Over the past decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective; we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Lecture notes

Available

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 948 of 2345
227-0447-00L  Image Analysis and Computer Vision  W  6 credits  3V+1U  E. Konukoglu, F. Yu  

Objective  Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content  This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes  Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice  Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

227-0526-00L  Power System Analysis  W  6 credits  4G  G. Hug  
Abstract  The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Objective  The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis tools in steady and dynamic states.

Content  The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes  Lecture notes.

227-0689-00L  System Identification  W  4 credits  2V+1U  R. Smith  
Abstract  Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.

Objective  To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.


Prerequisites / notice  Control systems (227-0216-00L) or equivalent.

227-0945-00L  Cell and Molecular Biology for Engineers I  W  3 credits  2G  to be announced  
Does not take place this semester.
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.


Lecture notes Scripts of all lectures will be available.

Literature A list of references is included in the handouts.

The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

### 151-0532-00L Nonlinear Dynamics and Chaos I

**Abstract**
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

**Objective**
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

**Content**
1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

**Lecture notes**
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

**Prerequisites / notice**
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

### 151-0573-00L System Modeling

**Abstract**
Introduction to system modeling for control. Generic modeling approaches based on first principles, Lagrangian formalism, energy approaches and experimental data. Model parametrization and parameter estimation. Basic analysis of linear and nonlinear systems.

**Objective**
Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.

**Content**
This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.

**Lecture notes**
The handouts in English will be available in digital form.

**Literature**
A list of references is included in the handouts.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Theory of Robotics and Mechatronics

151-0601-00L

W 4 credits 3G to be announced

Abstract
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Objective
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Content
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Lecture notes available.

Dynamic Programming and Optimal Control

151-0563-01L

W 4 credits 2V+1U R. D’Andrea

Abstract
Introduction to Dynamic Programming and Optimal Control.

Objective
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature

Prerequisites / notice
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Applied Compositional Thinking for Engineers II

151-9905-00L

W 4 credits 3G A. Censi, J. Lorand

Abstract
This course is an introduction to advanced topics in Applied Category Theory focused on the need of applications. The course favors a computational, constructive, and compositional approach targeted to specific applications in engineering.

Objective
In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of the problem and the design of the solution. However, the problem is that the type of math which could be useful to applications is not traditionally taught. Applied Category Theory is a new field of mathematics that could help thinking about compositionality.

However, there exists no easy path for learning it for engineers that is approachable and shows practical applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I), offered in Spring 2021.

This course’s goal is not to teach category theory for the sake of it. Rather, we will teach the “compositionality way of thinking”; category theory will be just the means towards it. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.

The course will favor a computational/constructive approach, highlighted even more in the second part of the class: each concept is accompanied by concrete exercises in the programming language Python.

The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.
**Categories**

- Functors

**Co-design problems**

- Naturality:
  - Natural transformations
  - Adjunctions
  - Traced monoidal categories

- Computation:
  - From mathematical models to algorithms
  - Solving finite co-design problems
  - Monads
  - Modeling uncertainty

**Enriched category theory:**

- Profunctors
- Enriched categories
- Negative category theory

**Wirings:**

- Operads
- Wiring diagrams

**Linear logic**

- Linear logic and DP

**Prerequisites / notice**

The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:

1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Algebra (sets, posets, relations, semigroups, groups).
3) Python programming.

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in Spring Semester are sufficiently proficient in (1)-(3).
Introduction to Mathematical Optimization

W 5 credits 2V+1U D. Adijashvili

Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Information about relevant literature will be given in the lecture.

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

Prerequisites / notice
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Target Group:
Students of higher semesters and PhD students of
- Medical Faculty, University of Zurich
- Biomedical Engineering, Robotics, Systems and Control
- D-MAVT, D-ITET, D-INFK, D-HEST
- Students of other departments, faculties, courses are also welcome

VideoTact, ForeThought Development, LLC. http://my.execpc.com/?dwysocki/videotac.html


Autumn Semester 2022
11 credits
Content

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.


Prerequisites / notice

Solid background in linear algebra.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

636-0007-00L Computational Systems Biology

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content

Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes

http://www.csb.ethz.ch/education/lectures.html

Literature


401-3055-64L Algebraic Methods in Combinatorics

Abstract

Does not take place this semester.

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.
Content

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure \( A \) one maps its elements to vectors in a linear space, and shows that the set \( A \) is mapped to linearly independent vectors. It then follows that the cardinality of \( A \) is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments
- Spaces of polynomials and tensor product methods
- Eigenvalues of graphs and their application
- The Combinatorial Nullstellensatz and the Chevalley-Warning theorem
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice

Students are expected to have a mathematical background and should be able to write rigorous proofs.

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

Abstract

Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

Objective

Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Content

Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more

Lecture notes

Lecture notes will be handed out as the course progresses.

Prerequisites / notice

solid basics in linear algebra and probability theory

<table>
<thead>
<tr>
<th></th>
<th>Neural Network Theory</th>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
<th>H. Bölcskei</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.</td>
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<tr>
<td>Objective</td>
<td>After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.</td>
<td></td>
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</tbody>
</table>
| Content | 1. Universal approximation with single- and multi-layer networks  
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory  
3. Fundamental limits of deep neural network learning  
4. Geometry of decision surfaces  
5. Separating capacity of nonlinear decision surfaces  
6. Vapnik-Chervonenkis (VC) dimension  
7. VC dimension of neural networks  
8. Generalization error in neural network learning |
| Lecture notes | Detailed lecture notes are available on the course web page https://www.mins.ee.ethz.ch/teaching/nnt/ |
| Prerequisites / notice | This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular. |

<table>
<thead>
<tr>
<th></th>
<th>Image Analysis and Computer Vision</th>
<th>W</th>
<th>6 credits</th>
<th>3V+1U</th>
<th>E. Konukoglu, F. Yu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 955 of 2345
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation

**Learning Dynamical Systems**

**Literature**


**Prerequisites / notice**

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
Content

1. Discrete-time linear systems and filters:
   state-space realizations, z-transform and spectrum,
   decimation and interpolation, digital filter design,
   stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   probability, random variables, discrete-time stochastic processes;
   detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
   Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

227-0116-00L VLSI 1: HDL Based Design for FPGAs W 6 credits 5G F. K. Gürkaynak, L. Benini

Abstract

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes

Textbook and all further documents in English.

Literature


Prerequisites / notice

Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://lis-students.ee.ethz.ch/lectures/vlsi-i/

227-0155-00L Machine Learning on Microcontrollers W 6 credits 4G M. Magno, L. Benini

Abstract

Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly “smart”. This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the “internet-of-things”, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

Objective

Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

<table>
<thead>
<tr>
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<th>Objective</th>
<th>Subject-specific Competencies</th>
<th>Taught competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W 6 credits 5G</td>
<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.</td>
<td>Concepts and Theories</td>
<td>Sufficient mathematical maturity, in particular in linear algebra, analysis.</td>
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<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W 6 credits 4G</td>
<td>The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, the channel coding theorem, the source-channel separation theorem, and feedback capacity.</td>
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<tr>
<td>227-0421-00L</td>
<td>Deep Learning in Artificial and Biological Neural Networks</td>
<td>W 4 credits 3G</td>
<td>The main goal of this lecture is to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.</td>
<td>Analytical Competencies</td>
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</table>

**Prerequisites / notice**

Lecture notes
Script and exercise sheets. Books will be suggested during the course.

**Subject-specific Competencies**
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Taught competencies**
Subject-specific Competencies
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Integrated competencies**
- Analytical Competencies
- Problem-solving
- Critical Thinking
- Integrity and Work Ethics

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The lecture slides will be provided as a PDF after each lecture. This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used. The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).

2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

227-0477-00L Acoustics I W 3 credits 2G K. Heutschi

Abstract
Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.

Objective
Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

Content
Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.

263-5210-00L Probabilistic Artificial Intelligence W 8 credits 3V+2U+2A A. Krause

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

263-5255-00L Foundations of Reinforcement Learning W 5 credits 2V+2A N. He

Does not take place this semester.
Number of participants limited to 190.

The course will be offered again in FS23.

Abstract
Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control.

Objective
This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover "new" applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content
Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes
Lecture notes will be posted on Moodle.

Literature
Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepevsíri.

Prerequisites / notice
Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5300-00L Guarantees for Machine Learning W 7 credits 3V+1U+2A F. Yang, A. Sanyal

Number of participants limited to 30.

Abstract
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.
### Objective

By the end of the semester students should be able to:

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work.

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimentation as well as theoretical questions.

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in individual exercises, homeworks and potentially in the final project.

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

### Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

### Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"; "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td>assessed</td>
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<td>assessed</td>
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<td>assessed</td>
<td>Critical Thinking</td>
</tr>
</tbody>
</table>

### Prerequisites

**401-3901-00L Linear & Combinatorial Optimization**

**W 11 credits 4V+2U R. Zenklusen**

**Abstract**

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**

The goal of this course is to get a thorough understanding of various classic mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**

Key topics include:

- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Solid background in linear algebra.

Former course title: Mathematical Optimization.
### Subjects of General Interest

These courses are suitable for several special fields. Please consult your tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0377-10L</td>
<td>Physics of Failure and Reliability of Electronic Devices and Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>I. Shorubalko, M. Held</td>
</tr>
<tr>
<td>363-0790-00L</td>
<td>Technology Entrepreneurship</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>F. Hacklin</td>
</tr>
</tbody>
</table>

#### Prerequisites / notice

- Students are expected to have a mathematical background and should be able to write rigorous proofs.

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Waring theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

- The course website can be found at
- Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.
- Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Autumn Semester 2022

<table>
<thead>
<tr>
<th>401-3621-00L</th>
<th>Fundamentals of Mathematical Statistics</th>
<th>W</th>
<th>10 credits</th>
<th>4V+1U</th>
<th>S. van de Geer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course covers the basics of inferential statistics.</td>
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</table>

<table>
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<tr>
<th>401-3055-64L</th>
<th>Algebraic Methods in Combinatorics</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>B. Sudakov</th>
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<tr>
<td>Abstract</td>
<td>Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.</td>
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<td>Objective</td>
<td>The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.</td>
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<td>Content</td>
<td>Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools. One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to): Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Waring theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.</td>
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<td>This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.</td>
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<td>The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.</td>
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<tr>
<td></td>
<td>- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Students are expected to have a mathematical background and should be able to write rigorous proofs.</td>
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</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 961 of 2345
Content
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer
Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

Lecture notes
Lecture slides and case material

151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.

The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality.

Lecture notes
The handout is available in German and English.

Prerequisites / notice
“Visualization, Simulation and Interaction - Virtual Reality II” is recommended, but not mandatory.

Taught competencies
Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Techniques and Technologies
Social Competencies: Communication
Personal Competencies: Creative Thinking

Didactical concept:
The course consists of lectures and exercises.

Internship in Industry

Number Title Type ECTS Hours Lecturers
227-1550-00L Internship in Industry Only for Electrical Engineering and Information Technology MSc (Programme Regulations 2008).

Abstract
The main objective of the 12-week internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

Semester Projects

Number Title Type ECTS Hours Lecturers
227-1101-00L How to Write Scientific Texts Strongly recommended prerequisite for Semester Projects and Master Theses at D-ITET (MSc BME, MSc EET, MSc EST).

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, "in this paper" paragraph, scientific part, summary, equations, figures)
  * Topic 2: Structure of Scientific Presentations
  * Topic 3: Citation Rules and Citation Software
  * Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html

Prerequisites / notice
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.
Semester Project (Nr 1)  
Registration in myStudies required!  
Supervisor must be a professor at D-ITET or associated, see https://ee.ethz.ch/studies/master-s-programmes/main-master/projects-and-master-thesis.html  
The first semester project is compulsory both for students enrolled in the MSc EEIT under the 2008 regulations and for students enrolled under the 2018 regulations.

Abstract  
Semester projects are designed to train the students for independent scientific work. A project uses the student's technical and social skills acquired during the master's program. The semester project comprises 280 hours of work and is supervised by a professor.

Objective  
see above

Prerequisites / notice  
Supervisor must be a professor at D-ITET or associated, see https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html

Semester Project (Nr 2)  
Registration in myStudies required!  
Supervisor must be a professor at D-ITET or associated, see https://ee.ethz.ch/studies/master-s-programmes/main-master/projects-and-master-thesis.html  
The second semester project is compulsory for students enrolled in the MSc EEIT under the 2008 regulations, it is optional for students enrolled under the 2018 regulations.

Abstract  
Semester projects are designed to train the students for independent scientific work. A project uses the student's technical and social skills acquired during the master's program. The semester project comprises 280 hours of work and is supervised by a professor.

Objective  
see above

Prerequisites / notice  
Supervisor must be a professor at D-ITET or associated, see https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html

Science in Perspective  
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET  
see Science in Perspective: Language Courses ETH/UZH

Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

Abstract  
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective  
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content  
- Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, “in this paper” paragraph, scientific part, summary, equations, figures)
- Topic 2: Structure of Scientific Presentations
- Topic 3: Citation Rules and Citation Software
- Topic 4: Guidelines for Scientific Integrity

Literature  
ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html

Prerequisites / notice  
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1501-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>68D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Admission only if ALL of the following apply:

a) bachelor program successfully completed
b) (if applicable) acquired all credits from additional requirements for admission to msc program
c) (2018 regulations): acquired the minimum number of credits in the 'core courses' category
d) successfully completed the semester project(s)

Registration in mystudies required!
Supervisor must be a professor at D-ITET or associated,
The Master Program finishes with a 6-months Master Thesis which is directed by a Professor of the Department or a Professor of another Department who is associated with the D-ITET. Students gain the ability to conduct independent scientific research on a specific research problem.

### Course Units for Additional Admission Requirements

**The courses below are only available for MSc students with additional requirements.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-AAL</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>E-</td>
<td>6</td>
<td>8R</td>
<td>H.-A. Loeliger</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
<td></td>
<td></td>
<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust “inversion” of a linear filter.</td>
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</tr>
<tr>
<td>Content</td>
<td>1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.</td>
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<tr>
<td></td>
<td>2. The discrete Fourier transform and its use for digital filtering.</td>
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<tr>
<td></td>
<td>3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture Notes.</td>
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</tbody>
</table>

The courses below are only available for MSc students with additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0103-AAL</td>
<td>Control Systems</td>
<td>E-</td>
<td>6</td>
<td>8R</td>
<td>F. Dörfler</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
<td></td>
<td></td>
<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
</tr>
<tr>
<td>Abstract</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Content</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture Notes.</td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>
### Content

### Literature

### Prerequisites / notice
Prerequisites: Signal and Systems Theory II.
MATLAB is used for system analysis and simulation.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Enrolment</th>
<th>Credits</th>
<th>ECTS</th>
<th>Semester</th>
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<tbody>
<tr>
<td>227-0166-AAL</td>
<td>Analog Integrated Circuits</td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
<td>6 credits</td>
<td>8R</td>
<td>Autumn Semester 2022</td>
</tr>
<tr>
<td>227-0117-AAL</td>
<td>High Voltage Engineering</td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
<td>6 credits</td>
<td>8R</td>
<td>Autumn Semester 2022</td>
</tr>
</tbody>
</table>

### Abstract
This course provides a foundation in analog integrated circuit design based on CMOS technologies. The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

### Objective
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems. The basic design, circuits and techniques for analog integrated circuits will be taught in this course.

### Content
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

### Lecture notes
Handouts of slides. No script but an accompanying textbook is recommended.

### Literature

### Notice
MATLAB is used for system analysis and simulation.
<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td></td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>not assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Project Management</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Communication</td>
<td>not assessed</td>
<td></td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>

**Electrical Engineering and Information Technology Master - Key for Type**

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Energy Science and Technology Master

Core Courses

At least two core courses must be passed in each area.
All students must participate in the course offered in the area "Interdisciplinary Energy Management"

Electrical Power Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0122-00L</td>
<td>Introduction to Electric Power Transmission: System &amp; Technology</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>C. Franck, G. Hug</td>
</tr>
</tbody>
</table>

Abstract
Introduction to theory and technology of electric power transmission systems.

Objective
At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of transformers and lines, calculate stationary power flows and other basic parameters in simple power systems.

Content
Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems.

Lecture notes
Lecture script in English, exercises and sample solutions.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Theories</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Project Management</td>
<td>Sensitivity to Diversity</td>
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<tr>
<td></td>
<td></td>
<td>Negotiation</td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

ECTS

Introduction to Electric Circuits, 9th Edition

This course is targeting students who have no prior background in electrical engineering. Mathematical foundations of the circuit analysis, such as matrix operations and complex numbers will be briefly reviewed. This course is targeting students who have no prior background in electrical engineering. Lecture notes and exercises slides will be distributed after each lecture via moodle platform; additional materials to be accessed online (wileyplus)

Lecture notes

<table>
<thead>
<tr>
<th>Text</th>
<th>Page 967 of 2345</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students without a background in Electrical Engineering must take &quot;Electric Circuits&quot; before taking &quot;Introduction to Electric Power Transmission: System &amp; Technology&quot;</td>
<td></td>
</tr>
<tr>
<td>Students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials. The lecture is part of the focus &quot;Energy, Flows &amp; Processes&quot; on the Bachelor level and is recommended as a basis for a future Master in the area of energy. It is also a facultative lecture on Master level in Energy Science and Technology and Process Engineering.</td>
<td></td>
</tr>
</tbody>
</table>
The learning objectives of the course are:

- Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.
- Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to building up students' intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Thermodynamic systems, states and state variables</td>
<td></td>
</tr>
<tr>
<td>2. Properties of substances: Water, air and ideal gas</td>
<td></td>
</tr>
<tr>
<td>3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy</td>
<td></td>
</tr>
<tr>
<td>4. Second law of thermodynamics and entropy</td>
<td></td>
</tr>
<tr>
<td>5. Energy analysis of steam power cycles</td>
<td></td>
</tr>
<tr>
<td>6. Energy analysis of gas power cycles</td>
<td></td>
</tr>
<tr>
<td>7. Refrigeration and heat pump cycles</td>
<td></td>
</tr>
<tr>
<td>8. Nonideal gas equation of state and Joule-Thomson effect</td>
<td></td>
</tr>
<tr>
<td>9. Maximal work and exergy</td>
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<tr>
<td>10. Mixtures</td>
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</tr>
<tr>
<td>11. Chemical reactions and combustion systems; chemical and phase equilibrium</td>
<td></td>
</tr>
</tbody>
</table>

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## Energy Economics and Policy

### Number

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0503-00L</td>
<td>Principles of Microeconomics</td>
</tr>
</tbody>
</table>

**Objective**

The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture “Principles of Microeconomics” is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature


Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
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Interdisciplinary Energy Management

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Only for Energy Science and Technology MSc.

Abstract
This course will allow the students to get an interdisciplinary overview of the "Energy" topic. It will explore the challenges to build a sustainable energy system for the future. This will be done through the means of case studies that the students have to work on. These case studies will be provided by industry partners.

Objective
The students will understand the different aspects involved in designing solutions for a sustainable future energy system. They will have experience in collaborating in interdisciplinary teams. They will have an understanding on how industry is approaching new solutions.

Lecture notes
Descriptions of case studies.
Taught competencies

Subject-specific Competencies
- Concepts and Theories (assessed)
- Techniques and Technologies (not assessed)

Method-specific Competencies
- Analytical Competencies (assessed)
- Decision-making (assessed)
- Media and Digital Technologies (not assessed)
- Problem-solving (assessed)
- Project Management (assessed)

Social Competencies
- Communication (assessed)
- Cooperation and Teamwork (assessed)
- Customer Orientation (assessed)
- Leadership and Responsibility (not assessed)
- Self-presentation and Social Influence (not assessed)
- Sensitivity to Diversity (assessed)
- Negotiation (assessed)

Personal Competencies
- Adaptability and Flexibility (assessed)
- Creative Thinking (assessed)
- Critical Thinking (assessed)
- Integrity and Work Ethics (assessed)
- Self-awareness and Self-reflection (assessed)
- Self-direction and Self-management (assessed)

Method-specific Competencies

Analytical Competencies
- Decision-making (assessed)
- Problem-solving (assessed)

Social Competencies
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Industrial Internship

<table>
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<th>Lecturers</th>
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<td>227-1650-10L</td>
<td>Internship in Industry</td>
<td>O</td>
<td>12 credits</td>
<td></td>
<td>external organisers</td>
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</tbody>
</table>

Abstract
The main objective of the 12-week internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

Objective
see above

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E</td>
<td>0 credits</td>
<td></td>
<td>U. Koch</td>
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</table>

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, "in this paper" paragraph, scientific part, summary, equations, figures)
* Topic 2: Structure of Scientific Presentations
* Topic 3: Citation Rules and Citation Software
* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html
ETH "Scientific Integrity", see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

Electives

These courses are particularly recommended, other ETH-courses from the field of Energy Science and Technology at large may be chosen in accordance with your tutor.

Electrical Power Engineering

<table>
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<tr>
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<tbody>
<tr>
<td>227-0113-00L</td>
<td>Power Electronics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>J. W. Kolar</td>
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Abstract
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective
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Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with sine triangular carrier and individual carrier signals of the phases.

The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

- discussion of the field equations relevant for high voltage engineering.
- analytical and numerical solutions/solving of this equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components

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Basics of the switching behavior, gate drive and snubber circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications.

Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

Lecture notes and associated exercises including correct answers.

Prerequisites: Introductory course on power electronics is recommended.

**Qubits, Electrons, Photons**

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

**Objective**

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

**Content**

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

**Lecture notes**

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

**Notice**

!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

**Literature**


Supplementary material will be uploaded in Moodle.

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The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
### Taught competencies

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<td>Railway Systems I</td>
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<td>M. Meyer</td>
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</table>

### Abstract

Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

### Objective

- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

### Content

1. Einführung:
   1.1 Geschichte und Struktur des Bahnsystems
   1.2 Fahrdynamik
2. Vollbahnfahrzeuge:
   2.3 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
   2.2 Bremsen
   2.3 Traktionsantriebssysteme
   2.4 Hilfsbetriebe und Komfortanlagen
   2.5 Steuerung und Regelung
3. Infrastruktur:
   3.1 Fahrweg
   3.2 Bahnstromversorgung
   3.3 Sicherungsanlagen
4. Betrieb:
   4.1 Interoperabilität, Normen und Zulassung
   4.2 RAMS, LCC
   4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastvorträge

### Lecture notes

Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

### Prerequisites / notice

Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.
The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

The goals of this course are a) understanding the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations and b) performing effective simulations of primary equipment of electric power systems. The course is understood complementary to 227-0537-00L “Technology of Electric Power System Components”, but can also be taken separately.

The course should learn the fundamentals of the electromagnetic, thermal, mechanical, and coupled fields simulations necessary for modern product development and research based on virtual prototyping. She / he should also learn the theoretical background of the finite element method (FEM) and its application to low- and high-frequency electromagnetic field simulation problems. The practical exercises of the course should be done by using one of the commercially available field simulation software (Infolytica, ANSYS, and / or COMSOL).

After completing the course the student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.

This course is defined so and planned to be an addition to the module “227-0537-00L Technology of Electric Power System Components”. However, the students who are familiar with the fundamentals of electromagnetic fields could attend only this course without its 227-0537-00L complement.

The course should be done by using one of the commercially available field simulation software (Infolytica, ANSYS, and / or COMSOL). After completing the course the student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.

1. Electromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
   a. Short review of the governing equations
   b. Boundary conditions
   c. Initial conditions
   d. Linear and nonlinear material properties
   e. Coupled fields (electro-mechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgears (GIS)
   f. Electromagnetic compatibility (EMC)

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

5. Risk Management 1 (m2m, VaR, hpfc, volatility, cVaR)
6. Risk Management 2 (PaR)
7. Risk Management 3 (enterprise wide)

8. Energy Economics

9. Capacity auctions

10. Spot and OTC trading

11. Contract valuation (HPFC)

12. Forward and futures contracts

13. Risk management 1 (m2m, VaR, hptc, volatility, cVaR)

14. Risk management 2 (PaR)

15. European energy exchange EEX

16. Cross-border trading

17. Market model

18. Balance groups / balancing energy

19. Ancillary services

20. Market for ancillary services

21. Market place and organisation

22. Ancillary services

23. Ancillary services

24. Ancillary services

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Simulation of Photovoltaic Devices - From Materials to W Modules

Abstract
The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules and large scale photovoltaic systems.

Objective
Get an overview over the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to predict the performance of solar cells and modules.

Content
Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanoscale-based solar cells devices (bonus lecture)

Literature
- M. A. Green, „Solar cells: operating principles, technology, and system applications“, Prentice Hall, 1982.

Prerequisites / notice
Undergraduate physics, mathematics, semiconductor devices

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

227-0617-00L Solar Cells

Abstract
Physics, technology, characteristics and applications of photovoltaic solar cells.

Objective
Introduction to solar radiation, physics, technology, characteristics and applications of photovoltaic solar cells and systems.

Content
Solar radiation characteristics, physical mechanisms for the light to electrical power conversion, properties of semiconductors for solar cells, processing and properties of conventional Si and GaAs based solar cells, technology and physics of thin film solar cells based on compound semiconductors, other solar cells including organic and dye sensitized cells, problems and new developments for power generation in space, interconnection of cells and solar module design, measurement techniques, system design of photovoltaic plants, system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples.

Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

Lecture notes
Lecture reprints (in english).

Prerequisites / notice
Prerequisites: Basic knowledge of semiconductor properties.

Energy Flows and Processes

Number
Title
Type
ECTS
Hours
Lecturers

151-0123-00L
Experimental Methods for Engineers
W
4 credits
2V+2U

Abstract
The course presents an overview of measurement tasks in engineering environments. Different concepts for the acquisition and processing of typical measurement quantities are introduced. Following an initial in-class introduction, laboratory exercises from different application areas (especially in thermofluidics, energy, and process engineering) are attended by students in small groups.

Objective
Introduction to various aspects of measurement techniques, with particular emphasis on thermo-fluidic, energy, and process-engineering applications.
Understanding of various sensing technologies and analysis procedures. Exposure to typical experiments, diagnostics hardware, data acquisition, and processing. Study of applications in the laboratory. Fundamentals of scientific documentation and reporting.
Content

In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy technology, process engineering). Student participation in 8-10 laboratory experiments (study groups of 3-5 students, dependent on the number of course participants and available experiments). Lab reports for all attended experiments have to be submitted by the study groups. A final exam evaluates the acquired knowledge individually.

Lecture notes

Presentations, handouts, and instructions are provided for each experiment.

Literature


Prerequisites / notice

Basic understanding in the following areas:
- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

151-0163-00L Nuclear Energy Conversion

Abstract

Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding.

Objective

Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.

Content

Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the rector core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of rector technology.

Lecture notes

Hand-outs will be distributed. Additional literature and information on the website of the lab: https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00-nuclear-energy-conversion.html

Literature


151-0209-00L Renewable Energy Technologies

Abstract

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

Objective

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture notes

Lecture Notes containing copies of the presented slides.

Prerequisites / notice

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

151-0216-00L Wind Energy

Abstract

The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. These subjects are introduced through a discussion of the basic principles of wind energy generation and conversion, and a detailed description of the broad range of relevant technical, economic and environmental topics.

Objective

The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy.

Content

This mechanical engineering course focuses on the technical aspects of wind turbines; non-technical issues are not within the scope of this technically oriented course. On completion of this course, the student shall be able to conduct the preliminary aerodynamic and structural design of the wind turbine blades. The student shall also be more aware of the broad context of drivetrains, dynamics and control, electrical systems, and metrology, relevant to all types of wind turbines.

151-0221-00L Introduction to Modeling and Optimization of Sustainable Energy Systems

Abstract

This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

Objective

At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

Content

In the course "Introduction to Modeling and Optimization of Sustainable Energy Systems", the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

Lecture notes

Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

151-0251-00L Principles, Efficiency Optimization and Future Applications of IC Engines

Abstract


Objective

The students get familiar with operating characteristics and efficiency maximization methods of IC engines for propulsion and decentralized electricity (and heat) generation. To this end, they learn about simulation methods and related experimental techniques for performance assessment in a combination of lectures and exercises.
This lecture aims at introducing the students to the working principles and efficiency optimization methods for Internal Combustion (IC) engines which are expected to continue to play a very important role in transportation (long-haul heavy duty, marine) and decentralized combined heat and power generation. Following an overview of different applications and powertrains, the course will focus on the following topics: First, a generic overview of the history of IC-Engines is given, and the basic dimensions and specific engine-relevant terminology are introduced. Next, operating maps for different duty cycles are discussed, highlighting the benefits of individual powertrain configurations for different usage scenarios. The high-pressure thermodynamic process and combustion-induced heat release are analyzed in detail and the design of the combustion processes is discussed in view of further optimization of the energy conversion efficiency. The concept of boosting, its challenges and potential are also presented. In addition, flow field characteristics, convective and radiative heat transfer and combustion modes (Otto, Diesel and “multi-mode” cycles) will be discussed along with possible simulation methods. The course consists of lectures combined with exercises. In addition, several invited guest talks will be held by representatives from Swiss industrial companies active in this field. Provided the pandemic measures allow, visits to different engine test facilities are further envisioned.

Literature

Prerequisites /
This course provides background for the course 151-0254-00L "Environmental Aspects of Future Mobility" held in the Spring Semester, where the focus is on emission formation and minimization, exhaust gas after treatment systems and potentials of future synthetic/e-fuels in IC engines; all given in the broader context of a future mobility/transportation options (battery electric, hybrids, fuel cells etc.) and transformation pathways towards sustainability.

Taught
Subject-specific Competencies
Concepts and Theories            assessed

Method-specific Competencies
Techniques and Technologies      assessed

Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English

Literature


151-0254-00L
Combustion and Reactive Processes in Energy and Materials Technology

Abstract
The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials.

Objective
The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials. The lecture is part of the focus "Energy, Flows & Processes" on the Bachelor level and is recommended as a basis for a future Master in the area of energy. It is also a facultative lecture on Master level in Energy Science and Technology and Process Engineering.

Content

Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English

Literature


151-0565-00L
Vehicle Propulsion Systems

Abstract
Introduction to current and future propulsion systems and the electronic control of their longitudinal behavior

Objective
Introduction to methods of system optimization and controller design for vehicles. Understanding the structure and working principles of conventional and new propulsion systems. Quantitative descriptions of propulsion systems

Content
Understanding of physical phenomena and mathematical models of components and subsystems (manual, automatic and continuously variable transmissions, energy storage systems, electric drive trains, batteries, hybrid systems, fuel cells, road/wheel interaction, automatic braking systems, etc.).

Lecture notes
Vehicle Propulsion Systems -- Introduction to Modeling and Optimization

Prerequisites /
Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups

151-0569-00L
Process Simulation and Flowsheeting

Abstract
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheetsing and optimization problems.

Literature

Prerequisites /
Lectures of Prof. Dr. Ch. Onder and Dr. Ph. Elbert are also possible to be held in German.
Objective

This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Content

Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

Literature

An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice

A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

Energy Economics and Policy

Number   Title                              Type   ECTS   Hours   Lecturers
101-0577-00L An Introduction to Sustainable Development in the Built Environment W 3 credits 2G  G. Habert, D. Kaushal

Abstract

In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict. What does it mean for the built environment? This course provides an introduction to the notion of sustainable development when applied to our built environment.
Objective

At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods

- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

Lecture notes

All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

102-0317-00L Advanced Environmental Assessments

Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0317-00 Advanced Environmental Assessments (3KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

Abstract

This course deepens students' knowledge of the environmental assessment methodologies and their various applications.

Objective

This course has the aim of deepening students' knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the
- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret and environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

Content

- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

Lecture notes

No script. Lecture slides and literature will be made available on Moodle.

Literature

Literature will be made available on Moodle.

Prerequisites / notice

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5, 2)).

Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed

Personal Competencies

- Critical Thinking: assessed

102-0317-03L Advanced Environmental Assessment (Computer Lab)

Abstract

Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice

Objective

Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

### 102-0317-04L Advanced Environmental Assessment (Computer Lab II)

- **Not for master students in Environmental Engineering choosing module Ecological System Design as already included in Environmental and Computer Laboratory I (Year Course): 102-0527-00 and 102-0528-00.**

<table>
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<tr>
<th>Abstract</th>
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<tbody>
<tr>
<td>Technical systems are investigated in projects, based on the software and tools introduced in the course 102-0317-03L Advanced Env. Assessment (Computer Lab I). The projects are created around a complete but simplifed LCA study, where the students will learn how to answer a given question with target oriented methodologies using various software programs and data sources for env. assessment.</td>
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<tr>
<th>Objective</th>
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<tr>
<td>Become acquainted with utilizing various software programs for environmental assessment to perform a Life Cycle Assessment and learn how to address the challenges when analyzing a complex system with available data and software limitations.</td>
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<tr>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>Prerequisite is enrolment of 102-0317-00 Advanced Environmental Assessments and of 102-0317-03 Advanced Environmental Assessments (Computer Lab I) in parallel or in advance (both courses in HS).</td>
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### Taught competencies

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<tr>
<td>Method-specific Competencies</td>
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<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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### 102-0327-01L Implementation of Environmental and Other Sustainability Goals

<table>
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<tr>
<th>Sustainability Goals</th>
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<tbody>
<tr>
<td>Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0327-01 Advanced Environmental Assessments (2KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).</td>
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<tr>
<td>This course teaches approaches and methods to identify, assess and manage environmental and societal aspects in organisations, such as ISO 14001 or the ecobalance of organisations, and how such approaches fit into a management system.</td>
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<table>
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<tr>
<th>Objective</th>
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<tr>
<td>Students will learn to</td>
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<tr>
<td>- describe key sustainability problems of the current economic system and measuring units.</td>
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<tr>
<td>- describe the management system of an organisation and how to develop a sustainability orientation.</td>
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<td>- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)</td>
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<td>- explain the pros and cons of single score environmental assessment methods.</td>
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<td>- apply life cycle costing.</td>
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<td>- interpret stakeholder relations of an organisation</td>
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<tr>
<td>- (if time allows) describe sustainable supply chain management and stakeholder management</td>
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<tr>
<td>- Sustainability problems of the current economic system and its measuring units;</td>
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<td>- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;</td>
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<td>- Sustainability Opportunities and Innovation</td>
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<td>- The concept of 'Continuous Improvement'</td>
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<td>- Life Cycle Costing, Life Cycle Management</td>
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<td>- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts</td>
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<td>- single score env. assessment methods (Swiss ecopoints)</td>
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<td>- stakeholder management and sustainability oriented communication</td>
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<td>- an intro into sustainability issues of supply chain management</td>
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<tr>
<th>Content</th>
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<tr>
<td>Students will get small exercises related to course issues.</td>
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### Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### 363-0537-00L Resource and Environmental Economics

<table>
<thead>
<tr>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will get small exercises related to course issues.</td>
</tr>
</tbody>
</table>

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 980 of 2345
Abstract

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

Objective

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overrun of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature


363-0387-00L Corporate Sustainability W 3 credits 2G V. Hoffmann, J. Meuer, A. Nunez-Jimenez

Abstract

The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

Objective

Students
- assess the limits and the potential of corporate sustainability for sustainable development
- develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method.
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams with different output formats (tv-style debate, consultancy pitch, technology model walk-through, campaign video)

Content

In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share his insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

Lecture notes

http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Presentation slides will be made available on moodle prior to lectures.

Literature

Literature recommendations will be distributed during the lecture

Prerequisites / notice

TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

Abstract

The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective

- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

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Content

* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, “in this paper” paragraph, scientific part, summary, equations, figures)

* Topic 2: Structure of Scientific Presentations

* Topic 3: Citation Rules and Citation Software

* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature

ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html

ETH "Scientific Integrity", see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice

Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>227-1601-00L</th>
<th>Master's Thesis</th>
<th>O</th>
<th>30 credits</th>
<th>40D</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Only students who fulfill the following criteria are allowed to enroll for and start with their master thesis:</td>
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<tr>
<td></td>
<td>a. successful completion of the bachelor program;</td>
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<tr>
<td></td>
<td>b. any additional requirements necessary to gain admission to the master program EST have been successfully completed;</td>
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<tr>
<td></td>
<td>c. both the semester project and the internship have been successfully completed.</td>
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</tbody>
</table>

Registration in mystudies required!

Abstract

The master program in Energy Science and Technology culminates in a six months research project which addresses a scientific research questions on one's chosen area of specialization. The masters thesis is supervised by a program-affiliated faculty member and the topic must be approved in advance by the tutor.

Objective

see above

Energy Science and Technology Master - Key for Type

<table>
<thead>
<tr>
<th>W</th>
<th>Eligible for credits</th>
<th>Dr</th>
<th>Suitable for doctorate</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Earth and Climate Sciences Bachelor

Basic Courses I

First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-2001-02L</td>
<td>Chemistry I</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel</td>
</tr>
</tbody>
</table>

Abstract

General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

Objective

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content

1. Stoichiometry
   - Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
4. Basics of chemical thermodynamics
   - System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
6. Second law of thermodynamics
   - Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
9. Acids and bases
10. Dissolution and precipitation.
    - Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes

Online-Skript mit durchgerechneten Beispielen.

Literature


Weiterführende Literatur:


Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

401-0251-00L Mathematics I

Abstract

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Objective

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.
Content

1. Single-Variable Calculus:
review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

2. Linear Algebra and Complex Numbers:
systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

3. Ordinary Differential Equations:
separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

Literature

- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

Prerequisites / notice

Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.

First Year Additional Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0030-00L</td>
<td>Laboratory Course: Elementary Chemical Techniques</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>A. de Mello, F. Jenny, M. H. Schrotth</td>
</tr>
</tbody>
</table>

Abstract

This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g. investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

Objective

This course is intended to provide an overview of the Earth as a system, with emphasis on plate tectonic theory and the geological rock-cycle. Provides a basic introduction to geophysics and plate tectonic theory.

Content

Overview of the Earth as a system, with emphasis on plate tectonic theory and the geological rock-cycle. Provides a basic introduction to geophysics and plate tectonic theory.

Lecture notes

The script will be published on the web.

Prerequisites / notice

Exercises and short excursions in small groups (10-15 students) will be lead by student assistants. Specific topics in earth sciences will be discussed using examples and case studies. Hand samples of the major rock types will be described and interpreted. Short excursions in the region of Zurich will permit direct experience with earth science processes (e.g. earth surface processes) and recognition of earth science problems and solutions relevant for modern society (e.g. building materials, water resources). Working in small groups will allow for discussion and examination of actual earth science themes.

Basic Courses II

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0000-03L</td>
<td>Laboratory Course in Physics for Students in Earth Sciences</td>
<td>O</td>
<td>2</td>
<td>4P</td>
<td>A. Biland, A. Müller</td>
</tr>
</tbody>
</table>

Abstract

Enrollment is only possible under https://www.lehrbetrieb.ethz.ch/laborpraktika. No registration required via myStudies. For further information visit: https://ap.phys.ethz.ch

Only students from 3rd Semester BSc Earth Sciences on are admitted to this Laboratory Course.

Only students from 3rd Semester BSc Earth Sciences on are admitted to this Laboratory Course.

Objective

The central aim is to provide an individual experience of the physical phenomena and the basic principles of the experiment. By conducting simple physical experiments the student will learn how to properly use physical instruments and how to evaluate the results correctly.

Content

Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html

Lecture notes

Anleitungen zum Physikalischen Praktikum
### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0063-00L</td>
<td>Physics II</td>
<td>O</td>
<td>5</td>
<td>3V+1U</td>
<td>A. Vaterlaus</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to the concepts and tools in Physics, with the help of demonstration experiments. The Chapters treated are Electromagnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena. Whenever possible, examples relevant to the students' main field of study are given.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>A script will be distributed</td>
<td></td>
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<td></td>
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<tr>
<td>Douglas C. Giancoli, Physik, 3. erweiterte Auflage, Pearson Studium</td>
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<td>Hans J. Paus, Physik in Experimenten und Beispielen, Carl Hanser Verlag, München, 2002, 1068 S.</td>
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<td>Paul A. Tipler, Physik, Spektrum Akademischer Verlag, 1998, 1522 S., ca Fr. 120.-</td>
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<td>David Halliday, Robert Resnick, Jearl Walker, Physik, Wiley-VCH, 2003, 1388 S., Fr. 87.- (bis 31.12.03)</td>
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<td>dazu gratis Online Ressourcen (z.B. Simulationen): <a href="http://www.halliday.de">www.halliday.de</a></td>
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</tbody>
</table>

| 651-3400-00L    | Geochemistry I               | O    | 4    | 3G    | M. Schönbächler, D. Vance |
| **Abstract**    | Introduction to geochemistry and its application to the study of the origin and evolution of the Earth and planets. |
| **Objective**   | Gain an overview of geochemical methods used in various fields of Earth Sciences and how they can be applied to study geological processes in the Earth's mantle, crust, oceans and atmosphere. |
| **Content**     | This course is an introduction into geochemistry with a special focus on the basic concepts used in this rapidly evolving field. The course deals with the geochemist's toolbox: the basic chemical and nuclear properties of elements from the periodic table and how these elements can be used to ask fundamental questions in Earth Sciences. The important concepts used in solid-solution-gas equilibria are introduced. The concepts of chemical reservoirs and geochemical cycles are discussed with examples from the carbon cycle in the Earth. The course also addresses geological applications in low- and high-temperature geochemistry, including the formation of continents, the differentiation of the Earth, the geochemistry of ocean and continental waters. |
| **Lecture notes** | The slides are available online. |
| **Prerequisites / notice** | Prerequisite: chemical thermodynamics, basic inorganic chemistry and physics. |
| 701-0023-00L    | Atmosphere                  | O    | 3    | 2V    | E. Fischer, T. Peter |
| **Abstract**    | Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer. |
| **Objective**   | Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere. |
| **Content**     | Basic principles of the atmosphere, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer. |
| **Lecture notes** | Written information will be supplied. |

### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0071-00L</td>
<td>Mathematics III: Systems Analysis</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>C. Brunner, R. Knutti, S. Schemm, H. Wernli</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Overhead slides will be made available through the course website.</td>
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</tbody>
</table>

| 651-3543-00L    | Geophysics I                 | O    | 4    | 2V+1U | D. Giardini, M. O. Saar |

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 985 of 2345
We will study traces in the lithosphere that have been left behind by organisms during the course of Earth history and mineral components, to understand and describe the basic principles of the hydrologic cycle and water flow in streams and aquifers.

To discuss surface and groundwater as a water resource.

To interpret different ion distributions in aquifers in terms of basic water chemistry, fluid-mineral reactions, water contamination, and water origin.

To understand the major features of ocean basins and the tectonic controls on their structure.

To describe how these controls interact to drive surface and interior ocean circulation.

To interpret different kinds of element distribution in the oceans in terms of basic chemistry, sinks, sources and internal biogeochemical cycling.

To discuss the cycles of carbon and oxygen in the ocean, with a view to the critical analysis of how the oceans respond to, cause and record the dynamics of these cycles in Earth history.

To discuss and describe the basic principles of the hydrologic cycle and water flow in streams and aquifers.

The hydrogeology component will: 1) describe the hydrologic cycle, with a focus on the importance of groundwater to society; introduce the basic physical aspects of groundwater flow, including Darcy's law, hydraulic head, hydraulic conductivity, aquifers; 2) describe the basics of groundwater chemistry, including major ions and mean meteoric water line, basics of groundwater contamination; 3) introduce the interface with the oceans, including hydrothermal circulation at mid-ocean ridges, ocean-water intrusion into groundwater at coasts.

The oceanography component will: 1) provide an overview of the physical circulation of the oceans, including its importance for heat transfer around the surface of the Earth and for climate; 2) describe the basic processes that control the chemistry of the oceans, including its temporal and spatial variability; 3) introduce some simple concepts in biological oceanography, including the dependence of ocean ecology on nutrient distributions. There will be a specific focus on how the physics, chemistry and biology of the ocean might have changed through Earth history, and the impact of oceanic processes on Earth's climate.

This course provides an introduction to oceanography and hydrogeology, with a special focus on the basic physicochemical concepts that control the properties and behaviour of two major reservoirs of water on Earth.

The course will allow you to ask questions about the origin and the evolution of life on Earth, to understand contemporary hypotheses and create new methods of developing them further. Theory is supplemented with observations in the field, exercises and the application of simple mathematical models. The course will enable you to integrate geobiological knowledge into topics that will be taught in subsequent earth science courses and into the current understanding of Earth history. You will learn to better understand modern geological settings and, if necessary, to recommend biogeochemically well-founded and responsible interventions or protective measures.

The course focuses on (a) geochemical cycles that play major roles in Earth history in aquatic and terrestrial ecosystems, (b) biosynthetic and metabolic processes, which are essential for life, (c) organisms which regulate and maintain geochemical cycling, and (d) chemical signals of past life in the geological record.

Accordingly, we must understand how biological cells and its components are built from essential elements and molecules, how cells function and which life styles organisms developed, where organisms can exist and which factors select for their presence, where biologically useable forms of energy come from, and under which conditions they can be exploited, how biological metabolism can change environmental conditions and composition, which biological products can lead to signals preserved in the rock record, and how biomolecules and elements are altered in sedimentary deposits, how organic and inorganic components are cycled through the biosphere, and how biogeochemical cycles function, how "biological innovations" evolved and changed in response to environmental changes.

Applied Case Studies, which supplement and illustrate the contents:
- Scientific applications of geobiological knowledge are found in fields like Microbial Ecology, Geochemistry, Palaeontology, Sedimentology, Petrology, Ocean Research, Environmental Sciences, Astrobiology and Archaeology.
- Practical applications of geobiological knowledge are needed in fields like stabilisation of existing and design of safe waste repositories, surveilling ground water resources, sewage treatment, exploitation of and prospecting for fossil carbon sources, soil remediation, mineral exploration and leaching, forensic science and medicine.

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**General Earth Sciences Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-3507-00L</td>
<td>Introduction to Oceanography and Hydrogeology</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>D. Vance, M. O. Saar</td>
</tr>
<tr>
<td>651-4143-00L</td>
<td>Geobiology</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>T. I. Eglinton, C. Magnabosco, C. Welte, S. Wohlenw</td>
</tr>
</tbody>
</table>

*Prerequisites / notice*

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 986 of 2345
Data Analysis and Visualisation with Python in Earth Sciences

To understand, qualitatively and semi-quantitatively, crystal and mineral formation, the interdependence between crystals structure, chemical composition and physical properties. This dependence is especially the case for the structural dependence of optical anisotropy and the elastic properties of the minerals as well as for the growth of crystals and their defect structures.

Prerequisites / notice

As integraler Bestandteil der Vorlesung wird eine Exkursion durchgeführt.

Mit der Belegung akzeptieren die Studierenden die Allgemeinen Geschäftsbedingungen für Exkursionen und Feldkurse des D-ERDW:
https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/studium/exkursionen/AGB_ERDW_Exkursionen_dt.pdf

651-3301-00L Crystals and Minerals O 4 credits 2V+3U M. Murakami, G. Speikermann

Abstract
To understand, qualitatively and semi-quantitatively, crystal and mineral formation, the interdependence between crystals structure, chemical composition and physical properties. This dependence is especially the case for the structural dependence of optical anisotropy and the elastic properties of the minerals as well as for the growth of crystals and their defect structures.

Objective
To understand, qualitatively and semi-quantitatively, crystal and mineral formation, the interdependence between crystals structure, chemical composition and physical properties. This dependence is especially the case for the structural dependence of optical anisotropy and the elastic properties of the minerals as well as for the growth of crystals and their defect structures.

Content
- Symmetrien und Ordnung, Punktklassen, Translationsklassen, Raumklassen.
- Chemische Bindungen, Beziehungen zwischen Struktur und Eigenschaften.
- Grundlagen von Thermodynamik und Computersimulationen in der Kristallographie.
- Einführung in die Mineralogie und Mineralanalyse.

Literature

651-4271-00L Data Analysis and Visualisation with Python in Earth Sciences O 3 credits 3G G. De Souza, A. Zunino

Abstract
This lecture and the corresponding exercises provide the students with an introduction to the concepts and tools of programming and scientific data analysis. Using examples from Earth Sciences, the students solve problems of increasing complexity using the programming language Python. Students also learn how to effectively visualise different kinds of datasets.

Objective
The following concepts are introduced in the course:
- Fundamentals of programming
- Analysis of datasets of differing types
- Effective and scientifically correct visualisation
- Statistical description of a dataset

651-3402-00L Magmatism and Metamorphose I O 4 credits 2V+1U M. W. Schmidt, P. Ulmer

Abstract
This course treats the generation and evolution of igneous rocks as well as the metamorphism of igneous and sedimentary rocks as products of geodynamic processes operating within the Earth’s interior.

Objective
This course combines petrography, geochemistry, experimental and theoretical petrology to assess fundamental igneous and metamorphic processes controlling the generation and evolution of igneous and metamorphic rocks in time and space. Principle targets are (1) the generation of magmas in the Earth mantle and crust, differentiation and emplacement of magmas at depth and on the surface and (2) metamorphism of igneous and sedimentary rock series and their relationships in the framework of global tectonics. The material is mostly presented in qualitative way. A quantification of igneous and metamorphic processes based on modal mineralogy, geochemistry, phase petrology and thermodynamic principles is assessed and further promoted in the accompanying homework and exercises.

Content
Introduction – Historic evolution – magmatism-metamorphism-tectonics
Earth mantle – composition, metamorphism, deep mantle mineralogy
Partial melting of the Earth’s mantle
Binary and ternary subsolidus and liquids phase diagrams
Tholeiitic magmatism – MORB and large igneous provinces (LIP)
Subduction zones – Magmatism at convergent plate margins, H2O-cycle
Geochemistry in igneous petrology
Igneous differentiation processes at convergent plate margins
Metamorphism of pelitic rocks (metapelites) and crustal melting
Material cycles at convergent plate margins

Lecture notes
Lecture notes and homework are provided and additional material is made available on Moodle.

Literature

Prerequisites / notice
7 homework assignments must be acceptably solved, the delivery of 9 acceptably solved homework assignments is acknowledged with an increase of the final grade by 0.25.

The end-of-term examination will take place in the two weeks scheduled in January.

Integrated Earth Systems

<table>
<thead>
<tr>
<th>^ Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4180-02L</td>
<td>Integrated Earth Systems II</td>
<td>O</td>
<td>5 credits</td>
<td>4G+1U</td>
<td>H. Stoll, D. Vance, S. Willett</td>
</tr>
</tbody>
</table>

Abstract
The surface Earth is often thought of as a set of interacting systems, often with feedbacks between them. These interacting systems control the tectonics, geomorphology, climate, and biology of the surface Earth. To fully understand the nature of the Earth System, including the controls on its past evolution, its present state, and its future, an integrated perspective is required.

Objective
To introduce students to an integrated view of the surface Earth, uniting perspectives from different disciplines of the earth sciences.

Content
Planet Earth has had a complex history since its formation ~4.6 billion years ago. The surface Earth is often thought of as a set of interacting systems, often with positive and negative feedbacks between them. These interacting systems control the tectonics, geomorphology, climate, and biology of the surface Earth. To fully understand the nature of the Earth System, including the controls on its past evolution, its present state, and its future, an integrated perspective is required.

We will achieve this integrated view through a series of lectures, exercises, and tutorials. We take as our framework some of the key events in Earth history, encouraging understanding of the controlling processes through integrated observations, ideas and models from disciplines across science.

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All participants are able to:

- Read and understand complex geological maps;
- Assess, select, and project information from real case studies;
- Make tectonic overview sketches and construct meaningful cross-sections;
- Advanced analysis of geological maps and construction of geological sections. Special points: normal faults of the Rheintal graben, Val de Ruz, Helvetic nappes of the Säntis area. Reconstruction of the geological history of the map areas. References to the Geology of Switzerland.

Lecture notes
Exercises and instructions are handed out.

Literature
Not required but for reference (in library holdings):

Prerequisites / notice
Requirement: Earth science mapping exercises I


Prerequisites / notice
Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

Voraussetzungen: Mathematik I, II

Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

Capacity to learn from data: good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.


Prerequisites / notice
Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

Voraussetzungen: Mathematik I, II

Introduction to the architecture and data processing capabilities of geographic information systems (GIS). Practical application of spatial data modeling and geoprocessing functions to a selected project from the earth sciences.

Theoretical introduction to the architecture, modules, spatial data types and spatial data handling functions of geographic information systems (GIS). Application of data modeling principles and geoprocessing capabilities using ArcGIS: Data design and modeling, data acquisition, data integration, spatial analysis of vector and raster data, particular functions for digital terrain modeling and hydrology, map generation and 3D-visualization.


Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information.

Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

The following methods will be discussed in detail: the radioactive-radiogenic systems Rb-Sr, Sm-Nd, U-Th-Pb and K-Ar, as well as the
development of basic knowledge and understanding of the applications of the most important systems of stable and radiogenic isotopes.

We will discuss how these methods are used in the following research fields: geochemistry of the earth, age dating, paleotemperature
reconstructions, evolution of the crust and mantle reservoirs, sediment diagenesis, fluid rock interactions, hydrothermal activity,
paleoceanography, biogeochemical cycles.

Lecture notes
Slides are provided online.

- Dickin A. P., Radiogenic Isotope Geology, (2005), Cambridge University Press
can be downloaded for free from http://csi.unm.edu

Prerequisites / notice
Prerequisites:
Geochemie I: (Bachelor course)

Applied

651-3501-00L Geochemistry II W+ 3 credits 2G S. Bernasconi, M. Schönbächler
Abstract
The course focuses on the most important systems of radioactive and stable isotopes used in geochemistry and geology. Applications of
isotope geochemistry for solving fundamental geological problems are discussed on the basis of case studies.

Objective
Development of a basic knowledge and understanding of the applications of the most important systems of stable and radiogenic isotopes.

Content
The following methods will be discussed in detail: the radioactive-radiogenic systems Rb-Sr, Sm-Nd, U-Th-Pb and K-Ar, as well as the
stable isotope systems of oxygen, carbon, nitrogen, sulfur and hydrogen.

Prerequisites / notice
Prerequisites:
Geochemie I: (Bachelor course)

651-4340-02L Geophysics III W+ 4 credits 3G A. Jackson, M.-A. Meier, P. Tackley
Abstract
This course builds on Geophyis I and Geophyis II, broadening the students' education in seismology, geodynamics and geodynamo
theory, by considering various specific topics of particular interest.

Objective
To teach students the basics of observational seismology, earthquake source seismology, seismotectonics and the principle of seismic
tomography, mantle convection over Earth history, structure of the oceanic and continental lithosphere, plate tectonics, hotspots, global
heat flux, dynamo operation and magnetic field generation in Earth, planets, the Sun and stars and electromagnetism to probe the mantle.

Content
Observational seismology, earthquake source seismology, seismotectonics and the principle of seismic tomography. Mantle convection
over Earth history, structure of the oceanic and continental lithosphere, plate tectonics, hotspots, global heat flux. Dynamo operation and
magnetic field generation in Earth, planets, the Sun and stars; electromagnetism to probe the mantle.

Lecture notes
Written course documentation available under "Kursunterlagen".

Literature

651-3525-00L Introduction to Engineering Geology W+ 4 credits 2V+1U L. de Palézieux dit Falconnet, M. Ziegler
Abstract
This introductory course starts from a descriptions of the behavior and phenomena of soils and rocks under near surface loading conditions
and their key geotechnical properties. Lab and field methods for the characterisation of soils, rocks and rock masses are introduced. Finally
practical aspects of ground engineering, including tunneling and landslidel hazards are presented.

Objective
Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of
rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

Content
Rock, soil and rock mass: scale effects and fundamental geotechnical properties. Soil mechanical properties and their determination. Rock
mechanical properties and their determination. Fractures: geotechnical properties and their determination. Geotechnical classification of
intact rock, soils and rock masses. Natural and induced stresses in rock and soil. Interaction of soil masses with surface loads, water and
evacuations. Slope instability mechanisms and stability analyses. Underground excavation instability mechanisms and rock deformation.
Geological mass wasting processes.

Lecture notes
Written course documentation available under "Kursunterlagen".

Literature
- Dickin A. P., Radiogenic Isotope Geology, (2005), Cambridge University Press
can be downloaded for free from http://csi.unm.edu

Prerequisites / notice
Prerequisites:
Geochemie I: (Bachelor course)
The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.

In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

Students are able to:
- qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,
- quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.

In this seminar, students learn to search efficiently for scientific literature and to present scientific findings orally and in written form.

Handouts will be distributed during the teaching semester and will be distributed and available on Moodle.

Further literature will be indicated during the lecture.

This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.

By the end of the course, students will be able to:
- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.
- develop, formulate and present solutions to these challenges to a critical audience.

Further literature will be distributed and available on Moodle.

Choice of courses from the complete offerings of ETH.

The Bachelor's Seminar is only offered in the spring semester.

In this seminar, students learn to search efficiently for scientific literature and to present scientific findings orally and in written form.

The students learn the principles of presenting scientific material orally. They become acquainted with the structure of scientific publications, and learn how to find, read and evaluate scientific literature. Furthermore, the course will introduce basic aspects of scientific writing.

Advisor of the BSc-major "Climate and Water" is Dr. Hanna Joos, Institute for climate and atmosphere (IAC).
701-0471-01L  Atmospheric Chemistry  W  3 credits  2G  M. Ammann, T. Peter
Abstract  This self-study course provides an introduction to atmospheric chemistry at bachelor level. It introduces the fundamentals of gas phase reactions, the concept of solubility and reactions in aerosols and in clouds. It explains the chemical and physical processes responsible for global (e.g. stratospheric ozone depletion) as well as regional environmental problems (e.g. urban air pollution).
Objective  The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere.
Content  - Origin and properties of the atmosphere: structure, large scale dynamics, UV radiation
- Thermodynamics and kinetics of gas phase reactions: enthalpy and free energy of reactions, rate laws, mechanisms of bimolecular and termolecular reactions.
- Tropospheric photochemistry: Photolysis reactions, photochemical Q3 formation, role and budget of HOx, dry and wet deposition
- Aerosols and clouds: chemical properties, primary and secondary aerosol sources, phase transfer kinetics, solubility and hygroscopicity, N2O5 chemistry, SO2 oxidation, secondary organic aerosols
- Air quality: role of planetary boundary layer, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Stratospheric chemistry: Chapman cycle, Brewer-Dobson circulation, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
- Global aspects: global budgets of ozone, methane, CO and NOx, air quality - climate interactions
Lecture notes  Lecture materials (slides and annotations) of the most recent corresponding bachelor course are provided.
Prerequisites / notice  Basic courses in chemistry and physics are expected.
701-0475-00L  Atmospheric Physics  W  3 credits  2G  F. Mahrt
Abstract  This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.
Objective  Students are able to
- to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.
Content  n the course "Atmospheric Physics", the competencies of process understanding, system understanding and data analysis & interpretation are taught, applied and examined. The competence measurement methods is taught as well.
The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.
Students also learn to classify radiosondes with the help the thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection.
Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.
With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.
Lecture notes  The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.
Prerequisites / notice  For certain capters we’ll use the concept of "flipped classroom" (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning.
We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.
Taught competencies  There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Subject-specific Competencies  Concepts and Theories  assessed
Method-specific Competencies  Analytical Competencies  assessed
Social Competencies  Communication  assessed
Personal Competencies  Critical Thinking  assessed
Self-direction and Self-management  assessed
651-3561-00L  Cryosphere  W  3 credits  2V  M. Huss, D. Farinotti, H. Zekollari
Abstract  The course introduces the different components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.
Objective  Students are able to
- qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,
- quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.
Content  In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.
The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.
Lecture notes  Handouts will be distributed during the teaching semester.
Further literature will be indicated during the lecture.

### Taught competences

|------------|---------------------------------------------------------------------|

### Method-specific Competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Communication</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
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</tr>
<tr>
<td>Negotiation</td>
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### Personal Competencies

<table>
<thead>
<tr>
<th>Adaptable and Flexibility</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>

### Literature

**701-0461-00L Numerical Methods in Environmental Physics**

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G</td>
<td>C. Schär, C. Zeman</td>
</tr>
</tbody>
</table>

**Abstract**

This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.

**Objective**

Ability to develop simple numerical schemes and to implement these schemes using the programming language Python. Ability to critically use more complex numerical models.

**Content**

Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration schemes, non-linearly, conservative numerical schemes, overview of other methods. Examples and exercises from a diverse cross-section of Environmental Science.

Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not necessary, a Python introduction is provided). Example programs and graphics tools are supplied.

**Lecture notes**


**List of literature provided.**

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**701-0473-00L Weather Systems**

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G</td>
<td>M. A. Sprenger, F. Scholder-Aemisegger</td>
</tr>
</tbody>
</table>

**Abstract**

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes

**Objective**

The students are able to

- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems

**Content**

- Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

**Lecture notes**

Lecture notes and slides

**Literature**

Atmospheric Science, An Introductory Survey

John M. Wallace and Peter V. Hobbs, Academic Press

**Prerequisites / notice**

Basic physics

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### Electives

The electives listed are recommended.

Additional courses can be chosen from the complete offerings of the ETH Zurich and University of Zurich.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
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</table>

#### Taught competencies

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### Literature

- Faraway (2005): *Linear Models with R*
- Faraway (2006): *Extending the Linear Model with R*
- Fox (2008): *Applied Regression Analysis and GLMs*
- Montgomery et al. (2006): *Introduction to Linear Regression Analysis*

### Prerequisites / notice

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

### Taught competencies

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- **Social Competencies**
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed

- **Personal Competencies**
  - Adaptability and Flexibility: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

### Taught competencies

#### Taught competencies

<table>
<thead>
<tr>
<th>Literature</th>
<th>Environmental Soil Physics/Vadose Zone Hydrology</th>
<th>W</th>
<th>3 credits</th>
<th>2V+1U</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0535-00L</td>
<td>Environmental Soil Physics/Vadose Zone Hydrology</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students are able to:</td>
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<tr>
<td></td>
<td>- characterize porous media at different scales</td>
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<td></td>
<td>- parameterize structural, flow and transport properties of partially-saturated porous media</td>
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<td></td>
<td>- quantify driving forces and resulting fluxes of water, solute, and heat in soils</td>
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<tr>
<td>Content</td>
<td>Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid, liquid and gaseous phases; soil water content; soil texture; particle size distributions;</td>
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<td></td>
<td>Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure</td>
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<td></td>
<td>Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab</td>
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<td></td>
<td>Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, and capillary rise); units and calculations and measurement of equilibrium soil water potential components</td>
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<td></td>
<td>Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab</td>
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<td>Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)</td>
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<td>Week 7: Unsaturated water flow in soils - unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow</td>
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<td></td>
<td>Week 8: Numerical solution of Richards equation – using Hydrus1D for simulation of unsaturated flow; choosing class project</td>
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<tr>
<td></td>
<td>Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow</td>
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<td></td>
<td>Week 10: Root water uptake and transpiration</td>
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<td></td>
<td>Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.</td>
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<td></td>
<td>Week 12: Summary of lectures; solution of old exam</td>
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<td></td>
<td>Week 13: Written semester-end exam</td>
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<td></td>
<td>Week 14: Short presentations of Hydrus class projects; discussion of written exam</td>
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</tr>
<tr>
<td>Literature</td>
<td>Supplemental textbook (not mandatory) -Introduction to Environmental Soil Physics, by: D. Hillel</td>
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</tr>
</tbody>
</table>

#### Taught competencies

<table>
<thead>
<tr>
<th>Literature</th>
<th>Environmental Fluid Dynamics</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0479-00L</td>
<td>Environmental Fluid Dynamics</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.</td>
<td></td>
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</tr>
</tbody>
</table>
Students are able
- to name the bases, concepts and methods of environmental fluid dynamics.
- to understand and discuss the components of the basic physical equations in fluid dynamics
- to apply basic mathematical equations to simple problems of environmental fluid dynamics.

The competencies of process understanding and system understanding are taught, applied and examined.

Basic physical terminology and mathematical laws:
Continuum hypothesis, forces, constitutive laws, state equations and basic principles of thermodynamics, kinematics, laws of mass and momentum on rotating earth.

Concepts and illustrative flow systems: vorticity dynamics, boundary layers, instability, turbulence - with respect to environmental fluid systems.

Scale analysis: dimensionless variables and dynamical similarity, simplification of the fluid system, e.g. shallow water assumption, geostrophic flow.

Waves in environmental fluid systems.

In english language
Will be presented in class.
See also: web-site.

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

401-0624-00L Mathematics IV: Statistics
W 4 credits 2V+1U J. Ernest

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

Objective
Capacity to learn from data: good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.

Content

Lecture notes
Ausführliches Skript zur Vorlesung ist erhältlich.

Literature

Prerequisites / notice
Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

Voraussetzungen: Mathematik I, II

401-6215-00L Using R for Data Analysis and Graphics (Part I)
W 1.5 credits 1G M. Mächler

Abstract
The course provides the first part an introduction to the statistical software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

Objective
The students will be able to use the software R for simple data analysis and graphics.

Content
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc.; simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15518
Choice of courses from the complete offerings of ETH.

Laboratory Course

The practical takes place in spring semester.

Bachelor’s Seminar

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0459-00L</td>
<td>Seminar for Bachelor Students: Atmosphere and Climate</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>R. Knutti, C. Brunner, O. Stebler</td>
</tr>
</tbody>
</table>

Abstract

In this seminar all students in the realm of atmospheric and climate science from D-ERDW and D-USYS convene to train presentation techniques (talks, posters) by means of classic and modern scientific articles.

Objective

In this seminar, students learn how to read scientific publications and how to transfer the scientific knowledge to a broader audience by means of oral and poster presentations. Students also get insight into the different research areas at the Institute for Atmospheric and Climate Science.

Content

1st week: course organisation and presentation of the institute
2nd and 3rd week: introduction to oral presentation technique
week 4 to 10: students talks
11th week: introduction to poster presentation technique
12th and 13th week: poster design
14th week: concluding poster presentation

Lecture notes

Documents are offered via the course's web page.

Literature

Documents are offered via the course's web page.

Prerequisites / notice

This course can only be offered to a limited number of students, however, in any case for everybody having to attend it compulsory. We beg you to sign in to this course early.

Science in Perspective

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ERDW

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Bachelor's Thesis

The Bachelor Thesis and Bachelor-Seminar are offered once per year in the 6th semester, in the spring semester.

Earth and Climate Sciences Bachelor - Key for Type

| W+       | Eligible for credits and recommended | Z         | Courses outside the curriculum |
| W        | Eligible for credits                | Dr        | Suitable for doctorate         |
| E-       | Recommended, not eligible for credits | O         | Compulsory                     |

Key for Hours

| V        | lecture                               | P         | practical/laboratory course    |
| G        | lecture with exercise                 | A         | independent project           |
| U        | exercise                              | D         | diploma thesis                |
| S        | seminar                               | R         | revision course / private study |
| K        | colloquium                            |           |                                 |

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Earth Sciences Master

Major in Geology

Compulsory Module in Analytical Methods in Earth Sciences

Students have to complete 6 credits in part A, and 6 credits in part B.

Part A: Microscopy Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4045-00L</td>
<td>Microscopy of Metamorphic Rocks</td>
<td>W+</td>
<td>2 credits</td>
<td>2G</td>
<td>A. Galli</td>
</tr>
</tbody>
</table>

Abstract

Objective
- Advanced knowledge in optical mineralogy
- Application of methods to determine minerals in thin sections
- Identification and characterization of metamorphic minerals
- Description of rocks. Derive correct petrographic rock name, based on modal abundance and microstructure/texture
- Interpretation of rock fabric/microstructure, parageneses and mineral reactions

Content
- Repetition of principal optical properties and of microscopic methods to identify minerals. Emphasis on interpretation of interference figures.
- Study typical metamorphic rocks in thin sections
- Description and interpretation of parageneses and texture/microstructures. Study the age relationship of crystallisation and deformation.
- Estimation of metamorphic grade
- Quantification. To determine volume percentage of rock components
- Scientific documentation: Descriptions, drawings, photomicrography using different kinds of illumination and using plane- or circular-polarised light.

Lecture notes
handouts with additional information on theory and for exercises, in English.

Literature
- Nesse, W.D.: Introduction to optical mineralogy. 3. Ed. (2004). Figures from this book will be used in lectures. Besides the theory, this book describes all optical properties of important minerals. Petrographers working on varying types of silicate rocks should have a look at this book.
- Also available in the D-ERDW library, NO building, on D-floor.

Prerequisites / notice
Number of participants 24.

Other microscopy courses at department D-ERDW are on:
- magmatic rocks, following this course in second half of semester (P. Ulmer, IGP; Inst. for Geochemistry and Petrology)
- sedimentary rocks (Geol. Institute)
- ore minerals (reflected light microscopy, Th. Driesner, IGP)
- microstructures, deformed rocks (Geol. Institute)

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>651-4047-00L</td>
<td>Microscopy of Magmatic Rocks</td>
<td>W+</td>
<td>2 credits</td>
<td>2G</td>
<td>P. Ulmer</td>
</tr>
</tbody>
</table>

Abstract
This course provides basic knowledge in microscopy of igneous rocks. Apart from the identification of common igneous minerals in thin sections, mineral assemblages, textures and structures will be investigated and the results of microscopy will be combined with igneous phase equilibria to understand generation, differentiation and emplacement of igneous rocks.

Objective
The principal goal of this course is to acquire expertise in:
(1) optical determination of minerals in igneous rocks using the polarizing microscope
(2) Identification of igneous rocks basing on modal mineralogy, structure and texture;
(3) Interpretation of textures and structures and associated igneous processes;
(4) Application of phase diagrams to natural rocks.

Content
This practical course bases on the course 'Microscopy of metamorphic rocks' (A. Galli), that is taught immediately before this course, where basic knowledge in optical mineralogy and the use of the polarizing microscope is acquired.
In this course, the most important (common) igneous minerals and rocks are studied in thin sections under the polarizing microscope.
Mineral assemblages, structures, textures and crystallization sequences are determined and utilized to understand the generation, differentiation and emplacement of igneous rocks. In addition, we will apply igneous phase equilibria that have been introduced in other lectures (such as magmatism and metamorphism I&II at ETH or an equivalent igneous petrology course) to natural rock samples in order to constrain qualitatively parent magma compositions and crystallization conditions.

Basis of the optical determinations of (igneous) minerals using the polarizing microscope are the tables of Tröger ('Optische Bestimmung der gesteinsbildenden Minerale', Optical determination of rock-forming minerals, 1982) that are available in sufficient number in the class room.

There are several good textbooks on the subject of 'mineralogy in thin sections' that I can suggest upon request.

The delivery of 3 acceptably solved homework assignments is acknowledged with an increase of the final grade by 0.25.

Other microscope courses taught at ETH Zurich at the D-ERDW are:
- Basics of optical mineralogy and petrography (M.W. Schmidt, BSc-course in German)
- Microscopy of metamorphic rocks (A. Galli, prerequisite for this course)
- Sedimentary Petrography and microscopy (V. Picotti & M.G. Fellin)
- Reflected Light Microscopy and Ore Deposits Practical (T. Driesner)
### Part B: Methods

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4055-00L</td>
<td>Analytical Methods in Petrology and Geology</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>J. Allaz, S. Bernasconi, M. Guillong, L. Zehnder</td>
</tr>
<tr>
<td>651-4113-00L</td>
<td>Sedimentary Petrography and Microscopy</td>
<td>W+</td>
<td>2</td>
<td>2G</td>
<td>V. Picotti, M. G. Fellin</td>
</tr>
<tr>
<td>651-4041-00L</td>
<td>&quot;Sedimentology I&quot; (651-4041-00L)</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>M. G. Fellin, A. Gilli, V. Picotti</td>
</tr>
<tr>
<td>651-4117-00L</td>
<td>Sediment Analysis</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>M. G. Fellin, A. Gilli, V. Picotti</td>
</tr>
<tr>
<td>651-0046-00L</td>
<td>Electron Microscopy Course (SEM and EPMA)</td>
<td>W+</td>
<td>3</td>
<td>3G</td>
<td>J. Allaz, L. Grafulha Morales</td>
</tr>
</tbody>
</table>

#### 651-4113-00L Sedimentary Petrography and Microscopy

**Abstract**

Microscopy of carbonate (1st half of semester) and siliciclastic rocks (2nd half) rocks as well as siliceous, phosphatic and evaporitic sediments.

**Objective**

Description of grains and cement/matrix, texture, classification of the main sedimentary rocks. Discussion and interpretation of the environment of sedimentation. Diagnostic Processes.

**Content**

- Microscopy of carbonate and siliciclastic rocks, siliceous and phosphatic rocks, their origin and classification. Diagenesis.

**Prerequisites / notice**

The earlier attendance of other MSc microscopy courses (e.g. magmatic and metamorphic rocks) is not required if during the BSc a general course on microscopy of rocks was completed.

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**651-4041-00L "Sedimentology I" (651-4041-00L)**

**Prerequisite:** Successful completion of the MSc-course "Sedimentology I" (651-4041-00L).

**Abstract**

Theoretical background and application of some basic methods for sediment analysis.

**Objective**

The main goal is to learn how to apply the analysis of the texture and grain-size of sediments to constrain the sedimentary processes and environments.

**Content**

A one-day fieldtrip to a local outcrop to learn how to describe sediments in the field and to collect samples for grain-size and compositional analysis. Application of the same analytical techniques on samples of unknown origin: the sampling sites will be revealed at the end of the course. Discussion of the theoretical background and of the results in class. At the end of the course, the student will have to hand in a report with the presentation and discussion of all the data produced during the course.

**Prerequisites / notice**

Introduction to clastic sedimentology. R.J. Cheel, Brock University

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**651-0046-00L Electron Microscopy Course (SEM and EPMA)**

**Abstract**

Theory and lab demo of scanning electron microscope (SEM) and electron microprobe analysis (EPMA) applied to geological materials: introduction to the instruments, interaction of electron with matter, electron imaging (SE, BSE, CL), electron backscatter diffraction (EBSD), X-ray analysis for the chemical characterisation of solid material at the micron-scale.

**Objective**

- Physical principles of electron microscopy: electron optics, interaction of electrons with matter, production of X-rays, interaction of X-rays with matter, X-rays detection and analysis. The second part of the course includes several demonstrations on various SEMs (at ERDW and Scopeml) and one EPMA at DERDW.

**Prerequisites / notice**

Microscopy of carbonate, siliciclastic rocks, siliceous and phosphatic rocks, their origin and classification. Diagenesis.

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**References**

  


Prerequisites / notice

No prerequisite required beside basic knowledge of petrology and mineralogy. Attending the "Analytical Methods in Geology and Petrology" prior to this course is an advantage.

Taught competencies

Subject-specific Competencies
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Cooperation and Teamwork: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

651-4063-00L X-Ray Powder Diffraction

W+ 3 credits 2G M. Plötze

Abstract

In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

Objective

Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.

Content

Fundamental principles of X-ray diffraction
- Setup and operation of X-ray diffractometers
- Interpretation of powder diffraction data
- Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes

Selected handouts will be made available in the lecture

Literature


Prerequisites / notice

The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential.

Software will be provided for future use on own Laptop.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Restricted Choice Modules Geology

A minimum of two restricted choice modules must be completed for the major Geology.

Biogeochemistry

Biogeochemistry: Compulsory Courses

The compulsory courses of the module take place in spring semester.

Biogeochemistry: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
</tr>
</tbody>
</table>

Abstract

The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.
Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving
forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and
stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

The student will be able to describe the natural factors that lead to variations in the earth's mean temperature, the growth and retreat of ice
sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret
evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use
data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to
compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with
predictions for climate changes over the next century to millennia.

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions mean the size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea
level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle. - How variable are the earth's precipitation regimes? How large are the ocean scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge.
Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With
flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams
will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

Palaeoclimatology

Palaeoclimatology: Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4057-00L</td>
<td>Climate History and Palaeoclimatology</td>
<td>W+</td>
<td>4</td>
<td>2G</td>
<td>H. Stoll, I. Hernández Almeida, H. Zhang</td>
</tr>
</tbody>
</table>

Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving
forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and
stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

The student will be able to describe the natural factors that lead to variations in the earth's mean temperature, the growth and retreat of ice
sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret
evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use
data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to
compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with
predictions for climate changes over the next century to millennia.
The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks on ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### Palaeoclimatology: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
</tr>
</tbody>
</table>

**Abstract**
The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

**Objective**
- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

**Content**
- carbonates: chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine sediments through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

**Literature**
We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

**Prerequisites / notice**
The grading of students is based on in-class exercises and end-semester examination.

### Sedimentology

#### Sedimentology: Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4041-00L</td>
<td>Sedimentology I: Physical Processes and Sedimentary Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>V. Picotti</td>
</tr>
</tbody>
</table>

**Abstract**
Sediments preserved a record of past landscapes. This courses focuses on understanding the processes that modify sedimentary landscapes with time and how we can read this changes in the sedimentary record.

**Objective**
The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.

**Content**
The sedimentary record of sea-level change
Angela Coe, the Open University.
Cambridge University Press

**Literature**
The grading of students is based on in-class exercises and end-semester examination.

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W</td>
<td>3</td>
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<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
</tr>
</tbody>
</table>

**Abstract**
The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.
Objective

You will understand chemistry and biology of the marine carbonate system.
- You will be able to relate carbonate mineralogy with facies and environmental conditions.
- You will be familiar with cool-water and warm-water carbonates.
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle.
- You will be able to calculate links between climate and marine carbon systems (e.g., acidification of oceans and reef growth).
- You will be able to use geological archives as source of information on global change.
- You will have an overview of marine sedimentation through time.

Content

- carbonates: chemistry, mineralogy, biology
- carbonate sedimentation from the shell to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corr. : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg,Ca, Sr
- marine sediments throughout geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

Lecture notes

no script. scientific articles will be distributed during the course

Literature

We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

Prerequisites / notice

The grading of students is based on in-class exercises and end-semester examination.

Sedimentology: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4901-00L</td>
<td>Quaternary Dating Methods</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>I. Hajdas, M. Christl, S. Ivy Ochs</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<tr>
<td></td>
<td>Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archaeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.</td>
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<tr>
<td>Objective</td>
<td>Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories. At the end of the course students will:</td>
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<tr>
<td></td>
<td>1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.</td>
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<td>2. be able to calculate an age based on data of the six methods studied.</td>
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<td>3. choose which dating method (or combination of methods) is suitable for a certain field problem.</td>
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<td>4. critically read and evaluate the application of dating methods in scientific publications.</td>
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<tr>
<td>Content</td>
<td>1. Introduction: Time scales for the Quaternary, Isotopes and decay</td>
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<tr>
<td></td>
<td>2. Radiocarbon dating: principles and applications</td>
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<td></td>
<td>3. Cosmogenic nuclides: 3He,10Be, 14C, 21Ne, 26Cl, 36Cl</td>
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<td>4. U-series disequilibrium dating</td>
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<td>5. Luminescence dating</td>
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<td></td>
<td>6. Introduction to incremental: varve counting, dendrochronology and ice cores chronologies</td>
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<td></td>
<td>7. Cs-137 and Pb-210 (soil, sediments, ice core)</td>
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<td></td>
<td>8. Summary and comparison of results from several dating methods at specific sites</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.</td>
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<td>Optional (individual):</td>
<td>1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggerebrg</td>
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</tbody>
</table>

| 651-4063-00L   | X-Ray Powder Diffraction        | W    | 3    | 2G    | M. Plötze |
|                | Number of participants limited to 18. |
|                | Abstract                       |      |      |       |           |
|                | In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters. |
| Objective      | Upon successful completion of this course students are able to: |
|                | - describe the principle of X-ray diffraction analysis |
|                | - carry out a qualitative and quantitative mineralogical analysis independently, |
|                | - critically assess the data, |
|                | - communicate the results in a scientific report. |
| Content        | Fundamental principles of X-ray diffraction |
|                | Setup and operation of X-ray diffractometers |
|                | Interpretation of powder diffraction data |
| Lecture notes  | Selected handouts will be made available in the lecture |
| Prerequisites / notice | The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data. |
|                | Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential. Software will be provided for future use on own Laptop. |

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1001 of 2345
Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Taught competencies

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies assessed
Problem-solving not assessed
Project Management not assessed
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Abstract
The transfer and redistribution of mass and chemical elements at the Earth's surface is controlled by a wide range of processes that will affect the magnitude and nature of fluxes exported from continental fluvial systems. This course addresses the production, transport, and deposition of sediments from source to sink and their interaction with biogeochemical cycles.

Objective
This course aims at integrating different earth science disciplines (geomorphology, geochemistry, and tectonics) to gain a better understanding of the physical and biogeochemical processes at work across the sediment production, routing, and depositional systems. It will provide insight into how it is actually possible to "see a world in a grain of sand" by taking into account the cascade of physical and chemical processes that shaped and modified sediments and chemical elements from their source to their sink.

Content
Lectures will introduce the main source to sink concepts and cover physical and biogeochemical processes in upland, sediment producing areas (glacial and periglacial processes; mass movements; hillslopes and soil processes/development; critical zone biogeochemical processes).

Field excursion (3 days, 30 September -2 October 2022): will cover the upper Rhône from the Rhône glacier to the Rhône delta in Lake Geneva as small scale source-to-sink system.

Practicals comprise (I) a small autonomous project on the Rhône catchment based on samples collected during the field trip and (II) an independent report on how you would design, build, and implement your own source-to-sink study.

Lecture notes
Lecture notes are provided online during the course. They summarize the current subjects week by week and provide the essential theoretical background.

Literature
Suggested references:
- "Sediment routing systems: the fate of sediments from Source to Sink" by Philip A. Allen (Cambridge University Press)
- "Principles of soilscape and landscape evolution by Garry Willgoose" (Cambridge University Press)
- "Geomorphology, the mechanics and chemistry of landscapes" by Robert S. Anderson & Suzanne P. Anderson (Cambridge University Press)

651-4343-00L Seismic Stratigraphy and Facies

W 3 credits 3G G. Eberli

Abstract
The course teaches the techniques of seismic interpretation for solving geological and environmental problems. A special focus is given to the seismic facies analysis and seismic sequence stratigraphy of different depositional systems. In addition, examples are presented how seismic data can be integrated into research projects in basin analysis, paleoceanography and paleoclimatology.

Objective
1. Acquire techniques for a comprehensive interpretation of seismic sections for solving geologic, stratigraphic and environmental problems
2. Correlation of seismic facies and seismic attributes to lithologic facies in different sedimentary systems
3. Learn the principles and techniques of seismic sequence stratigraphy and the differences between lithostratigraphy and sequence stratigraphy
4. Learn to integrate seismic data into paleoceanographic and paleoclimatic research.
The four day course consists of lectures that are accompanied by a variety of exercises.

Day 1:
Introduction seismic facies analysis with exercise
Seismic resolution
Seismic facies of contourite drift systems and their value as physical indicators of global current changes.

Day 2:
Seismic attributes and seismic geomorphology
Siliciclastic deltas, shelves and turbidite systems, 2D-3D
Exercise: Seismic section Tarragon Basin and reconstructing the basin evolution with respect to the climate conditions at the end of the Miocene.
Seismic facies carbonate systems
Carbonates as recorders of sea level and paleoclimate
Deepwater environments, including cold-water coral habitats

Day 3:
Carbonates versus volcanic seismic facies
Introduction seismic attributes
Faults and structures on seismic sections
Seismic facies of mixed systems with
Exercises from Canada and the Paradox Basin

Day 4:
Sea level and sedimentation
Telling ages on seismic section
Seismic stratigraphy and sequence stratigraphy
Exercise: Sequence analysis Straits of Andros
Final discussion

Lecture notes
An original script (110 pages) designed for the class will be distributed at the beginning of the course.

Literature
Books Seismic Interpretation of Depositional Systems:

Prerequisites / notice
Basic knowledge in sedimentology and stratigraphy

### Structural Geology

#### Structural Geology: Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4132-00L</td>
<td>Field Course IV: Non Alpine Field Course</td>
<td>W+</td>
<td>3</td>
<td>6P</td>
<td>W. Behr</td>
</tr>
</tbody>
</table>

Does not take place this semester.
Priority is given to D-ERDW students. If space is available UZH Geography and Earth System Sciences students may attend this field course at full cost.

No registration through myStudies. The registration for excursions and field courses goes through http://exkursionen.erdw.ethz.ch only.

Students who want to participate hand in a short motivation letter (max. 1 page A4). The final selection will be based on this motivation letter.
Deadline for motivation letter: 31 October 2018

Final decision 20 November 2018

Students registering for the course confirm having read and accepted the terms and conditions for excursions and field courses of D-ERDW https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/lehrgebiete/erdw/department/exkursionen/AGB_ERDW_Exkursionen_en.pdf

#### Structural Geology: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4111-00L</td>
<td>Experimental Rock Physics and Deformation</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td></td>
</tr>
</tbody>
</table>

Does not take place this semester.

We illustrate some physical properties, deformation mechanisms, and define flow laws. We show the fundamental techniques for the measurement in laboratory of density, permeability, elastic properties and deformation. We presented actual case studies and discuss upscaling from laboratory to field.
Objective

The objective of this course is to introduce rock physics and rock deformation, and discuss the aid of laboratory tests to interpretation at large scale.

Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the

Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the Earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics,

Content

The course will focus on research-based term project, lectures will alternate with laboratory demonstrations.

We will illustrate how to determined flow-laws of rocks from experiments and how to extrapolate to natural conditions. Since the time scale of laboratory experiments is several orders of magnitude faster than nature, we will compare the microstructure of natural rocks with that produced during the experiments to prove that the same mechanisms are operating. For this purpose, the fundamental techniques of experimental rock deformation will be illustrated and test on natural rock samples in the plastic deformation regime (high temperature) as well in the brittle regime (room temperature) will be presented. We will perform tests in the lab, to acquire the data, to correct for calibration and to process the data and finally to interpret the data.

The course is at Master student level, but will be useful for PhDs students who want to begin to work in experimental deformation or who want to know the meaning and the limitation of laboratory flow-laws for geodynamic modelling.

Prerequisites / notice

The course of Structural Geology (651-3422-00L) is highly recommended before attending this course. Moreover the students should have basic knowledge in geophysics and mineralogy/crystallography.

In doubt, please contact the course responsible beforehand.

651-3521-00L Tectonics W 3 credits 2V W. Behr, S. Willett

Abstract

Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Objective

Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information.

Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Content

Plate tectonic frame work: earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics, cycle of oceanic lithosphere, longlifety and growth of continents, supercontinents. Rheology of layered lithosphere and upper mantle. Obduction systems Collisions systems Extensional systems Basin evolution Passive and active continental margin evolution

Literature


Content
Lectures will introduce the main source to sink concepts and cover physical and biogeochemical processes in upland, sediment producing areas (glacial and periglacial processes; mass movements; hillslopes and soil processes/development; critical zone biogeochemical processes).

Field excursion (3 days, 30 September - 2 October 2022): will cover the upper Rhône from the Rhône glacier to the Rhône delta in Lake Geneva as small scale source-to-sink system.

Practicals comprise (i) a small autonomous project on the Rhône catchment based on samples collected during the field trip and (ii) an independent report on how you would design, build, and implement your own source-to-sink study.

Lecture notes
Lecture notes are provided online during the course. They summarize the current subjects week by week and provide the essential theoretical background.

Literature
Suggested references:
- "Sediment routing systems: the fate of sediments from Source to Sink" by Philip A. Allen (Cambridge University Press)
- "Principles of soilscape and landscape evolution by Garry Willgoose" (Cambridge University Press)
- "Geomorphology, the mechanics and chemistry of landscapes" by Robert S. Anderson & Suzanne P. Anderson (Cambridge University Press)

Basin Analysis: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4243-00L</td>
<td>Seismic Stratigraphy and Facies</td>
<td>W+</td>
<td>2 credits</td>
<td>3G</td>
<td>G. Eberli</td>
</tr>
</tbody>
</table>

Abstract
The course teaches the techniques of seismic interpretation for solving geological and environmental problems. A special focus is given to the seismic facies analysis and seismic sequence stratigraphy of different depositional systems. In addition, examples are presented how seismic data can be integrated into research projects in basin analysis, paleoceanography and paleoclimatology.

Objective
1. Acquire techniques for a comprehensive interpretation of seismic sections for solving geologic, stratigraphic and environmental problems
2. Correlation of seismic facies and seismic attributes to lithologic facies in different sedimentary systems
3. Learn the principles and techniques of seismic sequence stratigraphy and the differences between lithostratigraphy and sequence stratigraphy
4. Learn to integrate seismic data into paleoceanographic and paleoclimatic research.

Content
The four day course consists of lectures that are accompanied by a variety of exercises.

Day 1:
Introduction seismic facies analysis with exercise
Seismic resolution
Seismic facies of contourite drift systems and their value as physical indicators of global current changes.

Day 2:
Seismic attributes and seismic geomorphology
Siliciclastic deltas, shelves and turbidite systems, 2D-3D
Exercise: Seismic section Tarragon Basin and reconstructing the basin evolution with respect to the climate conditions at the end of the Miocene.
Seismic facies carbonate systems
Carbonates as recorders of sea level and paleoclimate
Deepwater environments, including cold-water coral habitats

Day 3:
Carbonates versus volcanic seismic facies
Introduction seismic attributes
Faults and structures on seismic sections
Seismic facies of mixed systems with
Exercises from Canada and the Paradox Basin

Day 4:
Sea level and sedimentation
Telling ages on seismic section
Seismic stratigraphy and sequence stratigraphy
Exercise: Sequence analysis Straits of Andros
Final discussion

Lecture notes
An original script (110 pages) designed for the class will be distributed at the beginning of the course.

Literature
Books Seismic Interpretation of Depositional Systems:

- "Geomorphology, the mechanics and chemistry of landscapes" by Robert S. Anderson & Suzanne P. Anderson (Cambridge University Press)
- "Principles of soilscape and landscape evolution by Garry Willgoose" (Cambridge University Press)
- "Sediment routing systems: the fate of sediments from Source to Sink" by Philip A. Allen (Cambridge University Press)

Earthquake Seismology

Prerequisites / notice
Basic knowledge in sedimentology and stratigraphy

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1005 of 2345
This course is a general introduction to the methods of seismic hazard analysis. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties.

### Abstract

This course is a general introduction to the methods of seismic hazard analysis. In the course it is explained how the disciplines of seismology, geology, strong-motion geophysics, and earthquake engineering contribute to the evaluation of seismic hazard. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties. The course includes the discussion related to Intensity and macroseismic scales, historical seismicity and earthquake catalogues, ground motion parameters used in the seismic hazard engineering, definitions of the seismic source, ground motion attenuation, site effects and microzoning, and the use of numerical tools to estimate ground motion parameters, both in a deterministic and probabilistic sense.

During the course recent earthquakes and their impacts are discussed and related to existing hazard assessments for the areas of interest.

### Hours

2G

### ECTS

3

### Lecturers

D. Fäh, M. Koroni

### Literature


W+ 3 credits 2G A. P. Rinaldi, T. Diehl

If you're interested in knowing more about the relationship between seismicity and plate tectonics, this is the course for you. (If you're not that interested, but your program of study requires that you complete this course, this is also the course for you.)

### Objective

The aim of the course is to obtain a basic understanding of the physical process behind earthquakes and their basic mathematical description. By the conclusion of this course, we hope that you will be able to:

- describe the relationship between earthquakes and plate tectonics in a more sophisticated and complete way
- explain earthquake source representations of varying complexity;
- address earthquakes in the context of different tectonic settings;
- explain the statistical behaviour of global earthquakes;
- describe and connect the ingredients for a seismotectonic study

### Content

The course features a series of 14 meetings, in which we review some fundamentals of continuum mechanics and tensor analysis required for a complete understanding of the relation between earthquakes and plate tectonics. Our goal is to help you understand deformation the small scale (fault) to the scale of plate tectonics. We will tell you about several ways to represent an earthquake source; we'll present these in order of increasing sophistication. You will enjoy (at least) a computer/class exercise and a guest lecture.

Topics covered in the course include:

- review of stress and deformation in the Earth, stress and strain tensors, rheology and failure criteria, fault stresses, friction and effects of fluids
- earthquake focal mechanisms; relationship between stress fields and focal mechanisms;
- seismic moment and moment tensors;
- crustal deformation from seismic, geologic, and geodetic observations;
- earthquake stress drop, scaling, and source parameters;
- global earthquake distribution; current global earthquake activity;
- different seismotectonic regions; examples of earthquake activity in different tectonic settings.

### Lecture notes

Course notes will be made available on a designated course web site. Most of the topics discussed in the course are available in the book mentioned below.

### Prerequisites / notice

Basic knowledge of continuum mechanics and rock mechanics, as well as notion of tensor analysis is strongly suggested. We recommend to have taken the course Continuum Mechanics (generally taught during the Fall semester).

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018.

The course will be evaluated in a final written test covering the topics discussed during the lectures.

The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS.

The course will be given in English.

### Earthquake Seismology: Compulsory Courses

One additional elective course of at least 3KP has to be completed for this Module according to prior agreement with the Subject Advisor (Autumn or Spring Semester).

### Geographic Information Systems

The courses of this module are offered by UZH and must be registered at UZH.

### Geographic Information Systems: Compulsory Courses

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: GEO372

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

This course is a general introduction to the methods of seismic hazard analysis. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties. The course includes the discussion related to Intensity and macroseismic scales, historical seismicity and earthquake catalogues, ground motion parameters used in the seismic hazard engineering, definitions of the seismic source, ground motion attenuation, site effects and microzoning, and the use of numerical tools to estimate ground motion parameters, both in a deterministic and probabilistic sense.

During the course recent earthquakes and their impacts are discussed and related to existing hazard assessments for the areas of interest.

### Hours

2G

### ECTS

5

### Lecturers

University lecturers

### Literature


W+ 5 credits 2V+2U

### Geomagnetics

The Courses of Choice are offered by UZH and must be approved by the subject advisor.

### Geomagnetics: Compulsory Courses

Courses are only offered in spring semester.

### Geographic Information Systems: Courses of Choice

The Courses of Choice are offered by UZH and must be approved by the subject advisor.
Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.

Objective

Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

At the end of the course students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. be able to calculate an age based on data of the six methods studied.
3. choose which dating method (or combination of methods) is suitable for a certain field problem.
4. critically read and evaluate the application of dating methods in scientific publications.

Content

1. Introduction: Time scales for the Quaternary, Isotopes and decay
2. Radiocarbon dating: principles and applications
3. Cosmogenic nuclides: 3He, 10Be, 14C, 21Ne, 26Cl, 36Cl
4. U-series disequilibrium dating
5. Luminescence dating
6. Introduction to incremental: varve counting, dendrochronology and ice cores chronologies
7. Cs-137 and Pb-210 (soil, sediments, ice core)
8. Summary and comparison of results from several dating methods at specific sites

Prerequisites / notice

Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.

Visit to Limno Lab and sampling a sediment core

Optional (individual): 1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggerebrg

Required: attending the lecture, visiting laboratories, handing back solutions for problem sets (Exercises)
In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

Selected topics of scientific research in Glaciology

Copies/pdf of scientific papers will be distributed during the course (moodle interface)

Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L Kryosphere
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

Taught competencies

Objectives:
- 651-4077-00L Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)

W 3 credits  1V University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO815

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.

Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes

Physics of Glaciers

W 3 credits  3G M. Lüthi, F. T. Walter, M. Werder

Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Will be provided on Moodle

A list of relevant literature is available on Moodle

High-school mathematics and physics knowledge required.

The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

The objectives of the courses are to:
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.
Content

The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Lecture notes

Digital lecture handouts will be distributed prior to each class.

Literature

Links to relevant literature will be provided during the classes.

Prerequisites / notice

Completed BSc studies. Basic knowledge in computer scripting in any language (e.g. Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.

Taught competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility not assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management assessed

Lithosphere Structure and Tectonics

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>651-3521-00L</td>
<td>Tectonics</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>W. Behr, S. Willett</td>
</tr>
</tbody>
</table>

Abstract
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Objective
Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Content
Plate tectonic frame work: earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics, cycle of oceanic lithosphere, longevity and growth of continents, supercontinents.
Rheology of layered lithosphere and upper mantle.
Obduction systems
Collisions systems
Extensional systems
Basin evolution
Passive and active continental margin evolution

Literature

Palaeontology

Palaeontology: Compulsory Courses

The compulsory courses take place in spring semester.

Palaeontology: Courses of Choice

The courses of choice are offered by UZH and must be registered at UZH.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>651-1380-00L</td>
<td>Palaeontological Excursions on Weekends (University of Zürich)</td>
<td>W</td>
<td>1</td>
<td>1P</td>
<td>University lecturers</td>
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No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO279
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4901-00L</td>
<td>Quaternary Dating Methods</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>I. Hajdas, M. Christl, S. Ivy Ochs</td>
</tr>
</tbody>
</table>

**Abstract**

Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.

**Objective**

Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. be able to calculate an age based on data of the six methods studied.
3. choose which dating method (or combination of methods) is suitable for a certain field problem.
4. critically read and evaluate the application of dating methods in scientific publications.

**Prerequisites / notice**

Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.

**Required**

- attending the lecture, visiting laboratories, handing back solutions for problem sets (Exercises)
- 1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggerebg
- visit to Limno Lab and sampling a sediment core
- Optional (individual): 1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggerebg

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<tbody>
<tr>
<td>651-4077-00L</td>
<td>Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)</td>
<td>W</td>
<td>3</td>
<td>1V</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

**Objective**

Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.

**Content**

- Erosion and sedimentation by glaciers as a function of topography, englacial temperature, sediment balance, sliding and melt water runoff. Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).
- Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

**Literature**

- references in script

**Prerequisites / notice**

Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes.

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**Note:** The courses of this module are offered by UZH and must be registered at UZH.

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**Remote Sensing:**

The courses of this module are offered by UZH and must be registered at UZH.

**Remote Sensing: Compulsory Courses**

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4263-00L</td>
<td>Remote Sensing and Geographic Information Science (University of Zurich)</td>
<td>W</td>
<td>5</td>
<td>2V+2U</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

**Remote Sensing: Courses of Choice**
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4269-00L</td>
<td>Specialisation in Remote Sensing: Spectroscopy of the Earth System (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>University lecturers</td>
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<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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<tr>
<td></td>
<td>UZH Module Code: GEO442</td>
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<tr>
<td></td>
<td>Prerequisite: Remote Sensing Methods (UZH Module Code: GEO0371)</td>
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<td>Mind the enrolment deadlines at UZH:</td>
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<td></td>
<td><a href="https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html">https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html</a></td>
</tr>
<tr>
<td>651-4257-00L</td>
<td>Specialisation in Remote Sensing: SAR and LIDAR (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>University lecturers</td>
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<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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<td></td>
<td>UZH Module Code: GEO443</td>
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<tr>
<td></td>
<td>Prerequisite: Remote Sensing Methods (UZH Module Code: GEO0371)</td>
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<td></td>
<td>Mind the enrolment deadlines at UZH:</td>
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</table>

#### Shallow Earth Geophysics
Courses are only offered in spring semester.

#### Modules from the Engineering Geology Major

Choice from Engineering Geology Required Modules

#### Modules from the Geophysics Major

Choice from Geophysics Compulsory Modules

Choice from Geophysics Restricted Choice Modules

#### Modules from the Mineralogy and Geochemistry Major

Choice from the Mineralogy and Geochemistry Restricted Choice Modules

#### Modules from the Major Geology Restricted Choice Modules

Choice from the Geology Restricted Choice Modules

#### Major in Engineering Geology

#### Compulsory Modules Engineering Geology

#### Engineering Geology: Fundamentals

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4025-00L</td>
<td>Rock Mechanics and Rock Engineering</td>
<td>O</td>
<td>4</td>
<td>4V</td>
<td>Q. Lei, to be announced</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course focusses on the principles (fundamentals) and basic concepts of rock mechanics and rock engineering (e.g. tunnelling, rock slope stability).</td>
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<tr>
<td>Objective</td>
<td>The course aims to introduce the fundamentals and basic concepts of rock mechanics and generic rock engineering. The student shall understand how rocks behave at different scales, under various artificial loads and in the shallow subsurface (a few km below ground). The link between rock mechanics, geology, hydrogeology and tectonics (i.e. the conditions under which the rock formed) will be clearly established.</td>
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<tr>
<td>Content</td>
<td>The student shall understand basic principles of rock mechanics and rock engineering. In addition, the student shall learn how to apply the results from lab and field investigations to simple engineering problems. This knowledge is required for subsequent integration courses (Landslide Analysis and Hazard Mitigation; Engineering Geology of Underground Excavations).</td>
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<tr>
<td>Lecture notes</td>
<td>Written course documentation available on our homepage: <a href="https://www.ethz.ch/content/specialinterest/erdw/geological-institute/engineering-geology/en/teaching/msc/fall/rock_mechanics.html">https://www.ethz.ch/content/specialinterest/erdw/geological-institute/engineering-geology/en/teaching/msc/fall/rock_mechanics.html</a></td>
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</table>

| 651-4033-00L   | Soil Mechanics and Foundation Engineering | O    | 4    | 3V    | M. Stolz, Q. Lei           |
| Abstract       | The course presents the principles of soil mechanics and soil behaviour characteristics and its applications in geotechnical structures and systems. It is based on more descriptive courses on Engineering Geology within the BSc Eng. Geol. Program and is a compulsory prerequisite for other courses within the MSc Eng. Geol. Program. |      |      |       |                            |
| Objective      | Understanding the principles of soil behaviour and the fundamentals of geotechnical practices in soils. Ability to communicate with geotechnical engineers. |      |      |       |                            |
| Content        | Soil Mechanics: Fundamental concepts of strength and deformation of different soils. Introduction to geotechnical calculations Significance of (ground)water Geotechnical Engineering in Soils: Evaluation of geotechnical scenarios, handling of forecast uncertainties, relation of soil properties and soil composition, interactions between soil and building, standard construction methods in soils (foundations, slopes, dams and levees), requirements for the geotechnical prognosis |      |      |       |                            |
| Lecture notes  | This lecture is supported by the textbook: "Geotechnical Engineering" by Donald P. Coduto, 2nd edition, 2011; ISBN-13: 978-0-13-135425-8 |      |      |       |                            |
Prerequisites / notice
Courses must be completed:
- Introduction to Engineering Geology (BSc level)
- Introduction to Groundwater
- Sedimentology and Quaternary deposits
- Principles of Physics
Courses recommended:
- Eng Geol Site Investigations
- Eng Geol Field Course I (soils)
- Clay Mineralogy

651-4023-00L Groundwater O 4 credits 4G X.-Z. Kong, B. Marti
Abstract
The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, formulating, and solving groundwater flow and solute transport problems.

Objective
a) Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions.
b) Students are able to formulate simple, practical groundwater flow and solute transport problems.
c) Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems.

Content
1. Introduction to groundwater problems. Concepts to quantify properties of aquifers.
2. Flow equation. The generalised Darcy law.
3. The water balance equation and basic concepts of poroelasticity.
5. Analytical solutions to flow problems
6. Finite difference scheme solution for simple flow problems.
10. Analytical solutions to transport problems.
11. Fractured and karst aquifers.
12. The unsaturated zone and capillary pressure.
13. Examples of applied hydrogeology from Switzerland and around the world. (Given by Dr. Beatrice Marti from Hydrosolutions Ltd.)

Lecture notes
Handouts of slides.

Literature
de Marsily G., Quantitative Hydrogeology, Academic Press, 1986

651-4025-00L Rock and Soil Mechanical Lab Practical O 3 credits 2P L. de Palézieux dit Falconnet, to be announced
Abstract
In this course, students will gain hands on experience performing laboratory and index tests commonly used in Rock and Soil Mechanics. The course is divided into two modules, with half the semester devoted to rock mechanic testing, and half to soil mechanics testing.

Objective
This course introduces the fundamentals of laboratory testing of rock and soil. Students will learn how to interpret laboratory data, the expected accuracy and limitations of common laboratory tests and the most appropriate testing method(s) for a given problem.

Content
In the Rock Mechanics lab, the following laboratory tests are performed: Ultrasonic velocity measurements, Point load test, Brazilian tensile test, Uniaxial compression test, Triaxial compression test. Through performing these experiments, students will get familiar with stress-strain curves, tensile, unconfined, and confined strength of rocks, Young’s modulus and Poisson ratio, and finally cohesion and friction angle of intact rocks.

In the Soil Mechanics Lab, the following seven laboratory tests are performed: Sieve Analysis, Hydrometer Analysis, Atterberg Limits, Proctor Compaction, Direct Shear Test, Falling Head Permeability and Consolidation Test. Through performing these tests, students gain an understanding of the relationship between index properties and soil behavior, as well as the strength, deformability and hydraulic characteristics of soils.

Lecture notes
Course materials are available in: https://www.ethz.ch/content/specialinterest/erdw/geological-institute/engineering-geology/en/teaching/msc/fall/rock-and-soil-mechanical-lab-practical.html

Prerequisites / notice
- 651-4025-00L Rock Mechanics and Rock Engineering
- 651-4033-00L Soil Mechanics and Foundation Engineering

651-4065-00L Geological Site Investigations O 3 credits 3G M. Ziegler
Abstract
This course introduces students to the methods used in characterising, developing or monitoring geotechnical engineering project sites. Measurements, tools and analyses are described that are relevant to determining the geologic conditions at a site as well as deformations that occur under natural or construction conditions.
Objective
This course aims at introducing the general procedures taken during an engineering geological site investigation. Students who complete the course should be able to design a site investigation program of measurements based on information from initial desk studies, and to analyse, integrate and interpret data from the measurement program.

Content
The methods that are routinely employed in site investigations will be described focusing on their applicability in different geologic environments. The limitations of the data in constraining the parameters of interest will be addressed together with problems of interpretation and cost-versus-information value. Specific topics addressed include drilling, coring, sampling, borehole testing, geophysical methods used in engineering geology, satellite, air- and ground-based surface and displacement monitoring (photogrammetry, LIDAR and Radar), and in-situ deformation measurement methods.

Lecture notes
Lecture notes will be available for download 1-2 days before each class.

Literature

Supplemental literature will be suggested and made available during the course.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

| Personal Competencies         | Adaptability and Flexibility | assessed |
|                               | Creative Thinking          | not assessed |
|                               | Critical Thinking          | assessed |
|                               | Integrity and Work Ethics  | not assessed |
|                               | Self-awareness and Self-reflection | assessed |
|                               | Self-direction and Self-management | not assessed |

Engineering Geology: Integration
Courses for this Module take place in spring semester.

Engineering Geology: Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4071-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>12 credits</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

Prerequisites: successful participation in all 3 compulsory modules of the Major in Engineering Geology (Fundamentals, Methods and Integration).

The Industrial Internship of the Eng Geol Major takes place in the second MSc year after consultation with Dr. Heike Willenberg. Detailed regulations of this practical are published on the Engineering Geology Website.

Abstract
The industry practical is supervised both from the industry partner and ETH and consists of technically and/or scientifically challenging work in the engineering geology domain. The regular duration of the practical is 10 weeks. The practical is is pre-defined in a work plan and concluded with a report written by the student.

Objective
The goals of the industry practical are to become familiar with technical, economic, legal and communication issues of real-life work in private industry or technical administration.

Major in Geophysics

Compulsory Modules Geophysics

Geophysics: Methods I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4005-00L</td>
<td>Geophysical Data Processing</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>C. V. Cauzzi, L. Ermert</td>
</tr>
</tbody>
</table>

Abstract
This course presents fundamental digital signal processing and filter theory with a focus on geophysical applications.

Objective
The goal of the course is to provide an understanding of the principles of digital signal processing and filter theory. Form: two hours lecture with two hours of computer based exercises per week over 7 weeks.

Content
Analog-digital conversion: dynamic range and resolution; Dirac-impulse, step function; Laplace transformation; Z-transformation; Differential equations of linear time-invariant systems; Examples: seismometer and RC-filter; Impulse response and transfer function; Frequency selective filters: example Butterworth filters; Digital filters: impulse invariance and bilinear transformation; Inverse filters; Response spectra.

Lecture notes
Lecture notes will be made available for download from the website of the course.

Literature
The class follows no single book. A list of relevant texts will be given in class.
The goal of this course is to introduce the students to some fundamental concepts of fluid dynamics, dimensional analysis and scaling.

A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.


Week 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


Grading will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

**Numerical Modelling I and II: Theory and Applications**

**Course Code:** 651-4241-00L

**ECTS Credits:** 6

**Type:** W+ 4G

**Instructor:** T. Gerya

**Objective:**

The goal of this course is to introduce the students to some fundamental concepts of fluid dynamics, dimensional analysis and scaling laws. A particular attention is given to the assumptions and approximations underlying the derivations of the equations in various situations. The lectures are a mix of table top experiments, everyday observations and theoretical derivations.

**Content:**

1) Fundamentals of fluid mechanics.
2) Ideal inviscid fluids.
3) Incompressible viscous fluids.

It includes, derivation of the Navier-Stokes equation for first principles, potential flows around, the Bernoulli theorem, the theorem of Kutta-Joukowski, origin of lift on a wing, elements of viscous boundary layer, lava flows, introduction to PIV and UDV measurements.

**Lecture notes:**

The slides of last year presentations will be made available at the beginning of the semester, they may be subject to changes during the lectures.

**Literature:**

Joukowski, origin of lift on a wing, elements of viscous boundary layer, lava flows, introduction to PIV and UDV measurements.

**Continuum Mechanics**

**Course Code:** 651-4007-00L

**ECTS Credits:** 3

**Type:** W+ 2V

**Instructor:** T. Gerya

**Objective:**

In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth's mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications.

**Lecture notes:**

The slides of last year presentations will be made available at the beginning of the semester, they may be subject to changes during the lectures.

**Literature:**

The goal of this course is to refresh and deepen students' knowledge in mathematical methods relevant to the problems arising in solid Earth physics. The course provides an overview on the most widely used seismological methods to image the Earth's interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Objective
Understand the strengths and weaknesses of various active and passive tomographic methods to image the structure of the Earth.

Content
A provisional week-by-week schedule (subject to change) is as follows:

Weeks 1-2: The continuity equation

Weeks 3-4: Density and gravity

Weeks 5-6: Stress and strain

Weeks 7-8: The momentum equation

Week 9: Viscous rheology of rocks
Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth’s interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws. Exercises: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Weeks 10-11: The heat conservation equation

Week 12-13: Elasticity and plasticity


GRADING will be based on homeworks (1/3) and oral exam (2/3).

Lecture notes
Script and Exam questions are available by request to gerya@ethz.ch

Literature

651-4130-00L Mathematical Methods W+ 3 credits 2G
A. Kuvshinov, M. Maflra

Abstract
The course guides students in learning mathematical machinery used to solve various physical problems. Special attention is paid to the analytical methods to solve partial differential equations describing physical processes such as heat transfer, electromagnetic induction, wave propagation, among others.

Objective
The goal of this course is to refresh and deepen students’ knowledge in mathematical methods relevant to the problems arising in solid Earth physics.

Content
The provisional subjects covered in this course are as follows:
(i) Vector calculus, vector identities, Parametric Curves and Surfaces
(ii) Calculus in curvilinear coordinates, Spherical and Cylindrical bases
(iii) Partial Differential Equations, Laplace equation, Helmholtz equation, Separation of variables, eigenvalues and eigenfunctions, spherical harmonic analysis
(iv) Special functions: Delta function, Heaviside function, Bessel functions, Green’s functions
(v) Tensors, Einstein notation, tensor algebra

Note: the actual content of the course may have slight deviations from the stated list.

Lecture notes
Current lecture notes and homeworks will be found during the course at www.polybox.ethz.ch

Literature
1. E. Kreyszig, “Advanced engineering mathematics”
2. M. Boas, “Mathematical methods in the physical science”
4. R. Snieder, “A guided tour of mathematical methods for the physical sciences”

Restricted Choice Modules Geophysics

Seismic Waves II

Autumn Semester 2022
The goal of this course is to enable students to understand current knowledge and uncertainties regarding the formation, structure, and evolution of planets and moons in our solar system and also apply it to ongoing discoveries regarding planets around other stars. Students will practice making quantitative calculations relevant to various aspects of these topics through weekly homeworks.

The main topics covered are: Orbital dynamics and Tides, Solar heating and Energy transport, Planetary atmospheres, Planetary surfaces, Planetary interiors, Asteroids and Meteorites, Comets, Planetary rings, Magnetic fields and Magnetospheres, The Sun and Stars, Planetary formation, Exoplanets and Exobiology.

It is recommended but not mandatory to buy one of these books:

Applied Geophysics

Applied Geophysics: Compulsory Courses
The compulsory courses take place in spring semester.

Applied Geophysics: Courses of Choice
The compulsory courses take place in spring semester.

Major in Mineralogy and Geochemistry

Compulsory Module in Analytical Methods in Earth Sciences
Students have to complete 6 credits in part A (microscopy courses), and 6 credits in part B (methods).

Microscopy Courses

Analytical Methods Courses

Restricted Choice Modules Mineralogy and Geochemistry
A minimum of two restricted choice modules must be completed in the major Mineralogy and Geochemistry.

Mineralogy and Petrology

Mineralogy and Petrology: Compulsory Courses

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
651-4028-00L | Physical Properties of Minerals | W+ | 3 credits | 2G | G. Spiekermann, P. Saha

Abstract
Physical properties of minerals, e.g. electrical properties, elastic, optical properties are discussed.
The effect of the crystal symmetry on the symmetry of physical properties as well as the mathematical formulation of the physical properties are major topics.

651-4039-00L | Thermodynamics Applied to Earth Materials | W+ | 3 credits | 2G |

Abstract
This course develops the thermodynamic concepts necessary to predict phase equilibria and to compute physical properties from thermodynamic data.

Objective
To provide students with the conceptual and practical skills necessary to implement thermodynamic models and data as provided in the earth science literature. The computer software package Maple is relied upon to allow students to solve realistic problems without the distraction of mathematical details.

Content
Elementary concepts (1st and 2nd Laws; composition, state and extent); stability criteria; Legendre transforms; Maxwell relations and other manipulations of thermodynamic functions; calculation of Gibbs energy for a pure solid; simple solution models; order-disorder solution models; reciprocal solution models; equations of state for molecular fluids; free energy minimization.

This course is neither an introduction to computer methods for calculating petrological phase equilibria nor an introduction to phase diagram methods.

Prerequisites / notice
The course is based on exercises assigned as homework.

Some familiarity with elementary thermodynamics (phase rule, reactions) and mathematics (differentiation, integration) is assumed.

Experience with Maple or comparable programs such as Mathematica is helpful.

Mineralogy and Petrology: Courses of Choice

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
651-4063-00L | X-Ray Powder Diffraction | W | 3 credits | 2G | M. Plötze

Abstract
In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

Objective
Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.

Content
Fundamental principles of X-ray diffraction
Setup and operation of X-ray diffractometers
Interpretation of powder diffraction data
Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes
Selected handouts will be made available in the lecture

Literature


Prerequisites / notice
The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

Software will be provided for future use on own laptop.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1017 of 2345
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

651-4233-00L Geotectonic Environments and Deep Global Cycles

W 3 credits 2V M. W. Schmidt, P. Ulmer

Abstract
This course addresses master students interested in an integral view of processes operating in various tectonic environments, most specifically divergent and convergent plate margins.

Petrology and Volcanology

Petrology and Volcanology: Compulsory Courses

The compulsory courses take place in spring semester.

Petrology and Volcanology: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>651-4063-00L</td>
<td>X-Ray Powder Diffraction</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Plötze</td>
</tr>
</tbody>
</table>

Number of participants limited to 18.

Abstract
In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

Objective
Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.

Content
Fundamental principles of X-ray diffraction
Setup and operation of X-ray diffractometers
Interpretation of powder diffraction data
Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes
Selected handouts will be made available in the lecture

Literature

Prerequisites / notice
The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.
Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential.
Software will be provided for future use on own Laptop.
Taught competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies assessed
Problem-solving not assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed

Personal Competencies

Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Geotectonic Environments and Deep Global Cycles

Mineral Resources: Compulsory Courses

Abstract

This course addresses master students interested in an integral view of processes operating in various tectonic environments, most specifically divergent and convergent plate margins.

Number Title Type ECTS Hours Lecturers
651-4233-00L Geotectonic Environments and Deep Global Cycles W 3 credits 2V M. W. Schmidt, P. Ulmer

Objective

Understanding the fundamental processes of hydrothermal, magmatic and supergene ore formation, recognising and interpreting mineralised rocks in geological context

Content

(a) Principles of hydrothermal ore formation: base metal deposits in sedimentary basins. Practical classification of sample suites by genetic ore deposit types

(b) Introduction to orthomagmatic ore formation. Chromite, Ni-Cu sulphides and PGE in layered mafic intrusions. Distribution coefficients between silicate and sulphide melts. Carbonatites and pegmatite deposits.

(c) Introduction to supergene residual deposits with emphasis on Ni laterites and bauxites

Literature

Extensive literature list distributed in course

Prerequisites / notice

2 contact hours per lecture / week including lectures, exercises and practical study of samples, and small literature-based student presentations. Supplementary contact for sample practicals and exercises as required. Credits and mark based on participation in course (exercises, 50%) and 1h30 written exam in the last lecture of the semester (50%).

Mineral Resources: Courses of Choice

Number Title Type ECTS Hours Lecturers

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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1019 of 2345
### 651-4069-00L Fluid and Melt Inclusions: Theory and Practice

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>3P</th>
<th>T. Driesner, G. Spiekermann, to be announced</th>
</tr>
</thead>
</table>

**Abstract**
Block course involving lectures, exercises and practical application of inclusion petrography, microthermometry, Raman and LA-ICPMS microanalysis

**Objective**
Practical ability to carry out a meaningful fluid or melt inclusion study in the fields of geochemistry, petrology or resource geology, involving problem definition, research planning, quantitative measurements using a combination of techniques, critical interpretation and correct documentation of results.

**Lecture notes**
Handouts with extensive list of primary literature available

**Literature**
Goldstein and Reynolds (1994): CD available for in-house use

### 651-4221-00L Numerical Modelling of Ore Forming Hydrothermal Processes

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>T. Driesner</th>
</tr>
</thead>
</table>

**Abstract**
Introduction to computer tools for the simulation of hydrothermal fluid flow and hydrothermal reactions. The computer programs are handed out to the students and can be run on normal laptop PCs (Windows operating system; MAC or Linux users will have to install a virtual machine or team up with a colleague with a Windows computer). No programming knowledge is necessary.

**Objective**
Learn how to use the simulation programs HYDROTHERM and Geochemist's Workbench to explore how hydrothermal or deposition works.

**Content**
Introduction to computer tools for the simulation of hydrothermal processes: HYDROTHERM for fluid flow simulations, Geochemist's Workbench for thermodynamic modeling. While learning the respective computer programs is an essential part of the course, the emphasis will be on using these tools to learn how the physics and chemistry of hydrothermal system actually work.

**Lecture notes**
Computer programs and course material will be distributed during the course.

**Literature**


### 651-4034-00L Resource Economics and Mineral Exploration

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>3P</th>
<th>C. Chelle-Michou</th>
</tr>
</thead>
</table>

**Abstract**
Global mineral economics and the strategies of mineral exploration -- including geological, geochemical and geophysical methods, but also non-geological factors such as organisational, political and environmental aspects. Changing external lecturers.

**Objective**
Practical understanding of the procedure of exploring a mineral prospect, based on geological analysis, exploration by drilling, resource calculation of tonnage and grade as a basis for economic evaluation for reporting to investors.

**Content**
This block course in will comprise 4 half-day lectures and a series of practical exercises from selection of a mineral property to discovery of mineral resources and their valuation. Teams are formed as Limited Partnership companies that have to select and bid for a mineral property offered during an auction. Each company has the same nominal budget. The highest bidder purchases the selected property, others need to purchase the remaining properties during an auction. Justification for selecting the property is justified in a report. The companies must interpret the geology of their mineral property to prepare a diamond drill program to discover and, eventually, delineate the mineral resources. This drill program is presented in a report prior to drilling. Drilling in the tri-dimensional matrix of the property is simulated using the software FOREUR, until budget lapse. The companies must select drill intervals for chemical analysis to document the extent and composition of the discovered mineralization. Portions of the mineral rights can be traded for capital between the companies. An estimate of the tonnage and grade of the discovered resource is prepared using geometric methods and GIS software (ex. ArcGIS). The ground value of the resource is estimated by a computation of the Net Smelter Return at current metal prices. The results of the exploration program are presented in a comprehensive report.

**Lecture notes**
Handouts for background information and a computer simulation program for the case-study exercise will be provided. Participants must bring a Windows-based laptop computer.

**Prerequisites / notice**
Prerequisites: Knowledge of mineral deposit-type characteristics is useful (orogenic gold, Cu-Zn VMS, Ni-Cu-PGE); at least "Integrierte Erdsysteme", "Ore Deposit 1", or adequate knowledge of mineral deposits acquired by preparatory reading. Basic knowledge of ArcGIS software is important to produce maps and sections required in reports. Training exercises and tutorials will be provided in advance to prepare for the course. Taught biennially in collaboration with University of Geneva.

This course is co-organised by ETH Zurich (Prof. C. Chelle-Michou) and University of Geneva (Prof. R. Moritz)

**Taught competencies**

<table>
<thead>
<tr>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

| Communication | not assessed |
| Cooperation and Teamwork | assessed |
| Customer Orientation | not assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity | not assessed |
| Negotiation | not assessed |

| Adaptable Flexibility | not assessed |
| Creative Thinking | assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | not assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and self-management | not assessed |

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### Geochemistry

#### Geochemistry: Compulsory Courses

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1020 of 2345
Geochemistry: Courses of Choice

Geochemistry: Courses of Choice

Abstract
This course will introduce some of the main quantitative methods available for the quantitative treatment of geochemical data, as well as the main modelling tools. Emphasis will both be on conceptual understanding of these methods as well as on their practical application, using key software packages to analyse real geochemical datasets.

Objective
Development of a basic knowledge and understanding of the main tools available for the quantitative analysis of geochemical data.

Content
The following approaches will be discussed in detail: major and trace element modelling of magmas, with application to igneous systems; methods and statistics for calculation of isochrons and model ages; reservoir dynamics and one-dimensional modelling of ocean chemistry; modelling speciation in aqueous (hydrothermal, fresh water sea water) fluids.

We will discuss how these methods are applied in a range of Earth Science fields, from cosmochemistry, through mantle and crustal geochemistry, volcanoanology and igneous petrology, to chemical oceanography.

A special emphasis will be put on dealing with geochemical problems through modeling. Where relevant, software packages will be introduced and applied to real geochemical data.

Number Title Type ECTS Hours Lecturers
651-4049-00L Conceptual and Quantitative Methods in Geochemistry W+ 3 credits 2G G. De Souza, T. Keller, B. J. Peters

651-4227-00L Planetary Geochemistry W+ 3 credits 2G M. Schönächler, H. Busemann, M. Ek

651-4233-00L Geotectonic Environments and Deep Global Cycles W 3 credits 2V M. W. Schmidt, P. Ulmer

651-4057-00L Climate History and Palaeoclimatology W 4 credits 2G H. Stoll, I. Hernández Almeida, H. Zhang

651-4225-00L Topics in Geochemistry W 3 credits 2G S. Bernasconi, M. Riebe, N. Shalev

Page 1021 of 2345
The purpose of this lecture is to provide a comprehensive overview of:

- the different radiometric methods in Geology, and
- the different dating methods.

Themes will vary from year to year and suggestions from students are welcome.

The goal of this course is to enable students to understand current knowledge and uncertainties regarding the formation, structure, dynamics and evolution of planets and moons in our solar system, as well as ongoing discoveries regarding planets around other stars.

Students will practice making quantitative calculations relevant to various aspects of these topics through weekly homeworks.

The main topics covered are: Orbital dynamics and Tides, Solar heating and Energy transport, Planetary atmospheres, Planetary surfaces, Planetary interiors, Asteroids and Meteorites, Comets, Planetary rings, Magnetic fields and Magnetospheres, The Sun and Stars, Planetary formation, Exoplanets and Exobiology.

Students will practice making quantitative calculations relevant to various aspects of these topics through weekly homeworks.

At the end students know the different isotope systems, methods and their application. Understand literature and critical reading and interpretation of published data is possible. For simple geochronological questions they can describe a scientific approach and possible solution. They can plot and interpret data using IsoplotR for different applications.

Content

- Introduction and overview, Data visualization and statistics in IsoplotR, Principles of U-Pb geochronology
- In situ U-Pb geochronology 1 (LA-ICPMS/SIMS principles, zircon)
- In situ U-Pb geochronology 2 (calcite, garnet, other minerals)
- High-precision ID-TIMS U-Pb geochronology (principles and applications)
- High-precision U-series geochronology (carbonates, silicates)
- K-Ar and 40Ar/39Ar geochronology , Principles and Applications
- Fission Track dating
1. U-Th/He dating
10. Thermochronology applications/lab visit
11. Noble gases - basics, reservoirs, geo/cosmochem. applications: mainly chronology
12. Cosmogenic nuclides (stable and radionuclides) - basics, geo/cosmochem. applications, C14

Lecture notes and Literature

- Slides and scripts will be posted on Moodle.
- It is recommended but not mandatory to buy one of these books:

Open Choice Modules

- Mineralogy and Geochemistry
- Metal isotopes as tracers for global geochemical cycles
- Noble gas geochemistry: terrestrial and extraterrestrial applications
- Isotope geochemistry of organic matter: carbon, hydrogen and nitrogen
- Clumped isotopes
- Mass-independent isotope fractionation
- Mass transfer and isotopes in modern and ancient ocean-floor hydrothermal systems and subduction zone environments.

Restricted Choice Module

- Isotopes and applications in geology and related fields
- Radiometric dating techniques and their applications
- Metal isotopes as tracers for global geochemical cycles
- Noble gas geochemistry: terrestrial and extraterrestrial applications
- Isotope geochemistry of organic matter: carbon, hydrogen and nitrogen
- Clumped isotopes
- Mass-independent isotope fractionation
- Mass transfer and isotopes in modern and ancient ocean-floor hydrothermal systems and subduction zone environments.

Restricted Choice Module of Mineralogy and Geochemistry

- Isotopes and applications in geology and related fields
- Radiometric dating techniques and their applications
- Metal isotopes as tracers for global geochemical cycles
- Noble gas geochemistry: terrestrial and extraterrestrial applications
- Isotope geochemistry of organic matter: carbon, hydrogen and nitrogen
- Clumped isotopes
- Mass-independent isotope fractionation
- Mass transfer and isotopes in modern and ancient ocean-floor hydrothermal systems and subduction zone environments.

Restricted Choice Module of Geophysics

- Isotopes and applications in geology and related fields
- Radiometric dating techniques and their applications
- Metal isotopes as tracers for global geochemical cycles
- Noble gas geochemistry: terrestrial and extraterrestrial applications
- Isotope geochemistry of organic matter: carbon, hydrogen and nitrogen
- Clumped isotopes
- Mass-independent isotope fractionation
- Mass transfer and isotopes in modern and ancient ocean-floor hydrothermal systems and subduction zone environments.

Restricted Choice Module of Engineering Geology

- Isotopes and applications in geology and related fields
- Radiometric dating techniques and their applications
- Metal isotopes as tracers for global geochemical cycles
- Noble gas geochemistry: terrestrial and extraterrestrial applications
- Isotope geochemistry of organic matter: carbon, hydrogen and nitrogen
- Clumped isotopes
- Mass-independent isotope fractionation
- Mass transfer and isotopes in modern and ancient ocean-floor hydrothermal systems and subduction zone environments.
## Electives

Courses can be chosen from the complete offerings of the ETH Zurich and University of Zurich (according to prior agreement with the subject advisor).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-1615-00L</td>
<td>Colloquium Geophysics</td>
<td>W</td>
<td>1</td>
<td>1K</td>
<td>A. Obermann, A. Zunino</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>This colloquium comprises geophysical research presentations by invited leading scientists from Europe and overseas, advanced ETH Ph.D. students, new and established ETH scientists with specific new work to be shared with the institute. Topics cover the field of geophysics and related disciplines, to be delivered at the level of a well-informed M.Sc. graduate/early Ph.D. student.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Attendants of this colloquium obtain a broad overview over active and frontier research areas in geophysics as well as opened questions. Invited speakers typically present recent work: Attendants following this colloquium for multiple terms will thus be able to trace new research directions, trends, potentially diminishing research areas, controversies and resolutions thereof, and thus build a solid overview of state and direction of geophysical research. Moreover, the diverse content and delivery style shall help attendants in gaining experience in how to successfully present research results.</td>
</tr>
<tr>
<td>651-0048-00L</td>
<td>Electron Microprobe Course 2 - Practice</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>J. Allaz</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Ability to operate the Electron Microscope with minimal assistance, optimise the analysis setup in order to obtain excellent results, identify possible source of error (troubleshooting) and fix them, data treatment (and interpretation).</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>Physical principles of electron optics, interaction of electrons with matter, production of X-rays, interaction of X-rays with matter. Detection of X-rays. Laboratory work in the field of Earth sciences.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>Script and User Manual will be provided.</td>
</tr>
</tbody>
</table>
|              | Prerequisites / notice                      |      |      |       | 4 full days.  
- Prerequisite: Analytical methods in Petrology and Geophysics (651-4055-00L) and 651-0046-00 Electron Microscope Course 1 - Theory |
|              | Taught competencies                        |      |      |       | Restricted attendance, max. 8 students (incl. Doctoral students and external participants). Contact J. Allaz. |
|              | Subject-specific Competencies              |      |      |       | Techniques and Technologies  
Analytical Competencies  
Decision-making  
Problem-solving  
Project Management  
Creative Thinking  
Critical Thinking |
|              | Method-specific Competencies               |      |      |       | assessed  
assessed  
assessed  
assessed  
assessed  
assessed  
assessed |
| 327-0703-00L | Electron Microscopy in Material Science    | W    | 4    | 2V+2U | S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze |
|              | Abstract                                   |      |      |       | A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials. |
|              | Objective                                  |      |      |       | A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials. |
|              | Content                                    |      |      |       | This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported. |
|              | Lecture notes                              |      |      |       | will be distributed in English |
Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015) |
| 651-3541-00L | Exploration and Environmental Geophysics   | W    | 4    | 3V    | P. Edme, H. Maurer, A. Shakas |
|              | Abstract                                   |      |      |       | Overview and understanding of the most important geophysical methods: Potential field methods (Gravimetrics and Magnetics), Electrical and electromagnetic methods, Refraction and reflection seisms, Georadar. Discussion of survey design, sources and receivers and data processing. |
|              | Objective                                  |      |      |       | Overview and understanding of the most important geophysical methods. Proposed solutions to assess and observe problems relevant to exploration and environmental geophysics in soil, ice and lithosphere at different scales. Getting familiar with measuring- and interpretation procedures. Pointing out the possibilities and limitations of geophysical methods. |
|              | Lecture notes                              |      |      |       | Available through eDoz/ILIAS. |
|              | Literature                                 |      |      |       | Additional material will be provided by the lecturers. |
| 651-4086-00L | Experimental Methods in Petrology          | W    | 3    | 2P    | C. Liebske, P. A. Sossi |
|              | Abstract                                   |      |      |       | Overview and understanding of the most important geophysical methods: Potential field methods (Gravimetrics and Magnetics), Electrical and electromagnetic methods, Refraction and reflection seisms, Georadar. Important geophysical (subsurface) Parameters. Operating procedures for sources and receivers. Principles of digital Signal Recording. Explanation of various steps of Digital Signal Processing. Outlook on advanced methods and interpretation procedures. Examples of specific problems, like landfills and rockslides. There will also be demonstrations in the Field. |
|              | Objective                                  |      |      |       | Overview and understanding of the most important geophysical methods: Potential field methods (Gravimetrics and Magnetics), Electrical and electromagnetic methods, Refraction and reflection seisms, Georadar. Important geophysical (subsurface) Parameters. Operating procedures for sources and receivers. Principles of digital Signal Recording. Explanation of various steps of Digital Signal Processing. Outlook on advanced methods and interpretation procedures. Examples of specific problems, like landfills and rockslides. There will also be demonstrations in the Field. |
|              | Content                                    |      |      |       | This colloquium comprises geophysical research presentations by invited leading scientists from Europe and overseas, advanced ETH Ph.D. students, new and established ETH scientists with specific new work to be shared with the institute. Topics cover the field of geophysics and related disciplines, to be delivered at the level of a well-informed M.Sc. graduate/early Ph.D. student. |
|              | Lecture notes                              |      |      |       | Attendants of this colloquium obtain a broad overview over active and frontier research areas in geophysics as well as opened questions. Invited speakers typically present recent work: Attendants following this colloquium for multiple terms will thus be able to trace new research directions, trends, potentially diminishing research areas, controversies and resolutions thereof, and thus build a solid overview of state and direction of geophysical research. Moreover, the diverse content and delivery style shall help attendants in gaining experience in how to successfully present research results. |
|              | Prerequisites / notice                      |      |      |       | 4 full days.  
- Prerequisite: Analytical methods in Petrology and Geophysics (651-4055-00L) and 651-0046-00 Electron Microscope Course 1 - Theory |
|              | Taught competencies                        |      |      |       | Restricted attendance, max. 8 students (incl. Doctoral students and external participants). Contact J. Allaz. |
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Analytical Competencies  
Decision-making  
Problem-solving  
Project Management  
Creative Thinking  
Critical Thinking |
|              | Method-specific Competencies               |      |      |       | assessed  
assessed  
assessed  
assessed  
assessed  
assessed  
assessed |

Data: 18.08.2022 12:39
Autumn Semester 2022
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Overview of the most common experimental methods employed in petrology to determine thermodynamic and physical properties and
phase equilibria of minerals, mineral assemblages, magmas and fluids. The basic principals of low, moderate, high and ultrahigh pressure
devices are discussed combined with an introduction into the synthesis of starting materials and the evaluation of run products.

This course shall provide the basics of experimental petrology. The principal goals are the acquisition of basic knowledge about
experimental equipment employed in petrology and the design and setup of an experimental study targeted to obtain quantitative data on
phase relations, thermodynamic, kinetic and rheologic properties of earth materials as well as the examination, analysis and evaluation of
experiments. At the end of the course, the participants should be able to evaluate experimental data independently and design appropriate
experiments on their own.

The course ‘Experimental methods in petrology’ covers the following subjects:

1. Introduction and historical summary of experimental petrology
2. Experimental methods at ambient pressure (1 bar) with practical exercise to determine the free energy of formation of wustite (FeO)
3. Experimental buffering techniques (phase rule, buffering of partial pressures of gases and supercritical fluids, buffering of mixed volatile
phases at elevated pressures, buffering of activities and solid-solid solutions in solid phases
4. Experimental methods at moderate pressures: externally (cold seal) and internally (IHPV) heated gas-pressure apparatus with practical
demonstration/exercise
5. High-pressure solid-media experimental techniques (piston cylinders)
6. Ultrahigh-pressure experimental techniques (multi-anvil apparatus, diamond-anvil-cells (DAC)
7. Evaluation of petrologic experiments (preparation of run products, analytical and spectroscopic methods of examination and
quantification)

The practical work in the laboratories are conducted (with the exception of exercise #1) on a small research project where the various

A summary of the material presented in the lectures is distributed weekly.

This course addresses to a public (master and PhD students) that is interested in an introduction to experimental petrology, but
does not require basic knowledge in experimental methods. However, basic knowledge in petrology and physical chemistry
(thermodynamics) is required to follow the course.

The course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience.
The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A
hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

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does not require basic knowledge in experimental methods. However, basic knowledge in petrology and physical chemistry
(thermodynamics) is required to follow the course.

The practical work in the laboratories are conducted (with the exception of exercise #1) on a small research project where the various
techniques and equipment are demonstrated and the practical use is trained.

Currently, there is no comprehensive book available that summarizes the most important aspects of experimental petrology; publications
relating to individual subjects are referred during the lectures.

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hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.
651-1392-00L  Palaeontological Colloquium (University of Zurich)  E-  0 credits  1K  University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO571

Abstract
Talks and discussion on current topics in Palaeontology (Palaebotany, Palaeozoology and Micropalaeontology).

Objective
Spezielle Vertiefung paläontologischer Kenntnisse.

Content
Vorträge von Institutsangehörigen und eingeladenen Gästen aus dem In- und Ausland über aktuelle Themen aus dem Gesamtgebiet der Paläontologie (Palaëobotanik, Paläozoologie und Mikropaläontologie) mit anschliessender Diskussion.

651-4101-00L  Seminar in Seismology  W  3 credits  3G  M. Lüthi, F. T. Walter, M. Werder

Abstract
Talks and discussion on current topics in Seismology. The seminars present current problems and research activities in the seismological community.

Objective
Organisation von Talken und Diskussionen zu aktuellen Themen der Seismologie.

Content
The seminars are open to all interested researchers and students. They will be well equipped to work on seismology-related problems by numerical modeling, remote sensing, and field work.

Lecture notes
Will be provided on Moodle

651-0254-00L  Seminar Geochemistry and Petrology  E-  0 credits  2S  O. Bachmann, M. Schönäbächler, C. Chelli-Michou, M. W. Schmidt, D. Vance

Abstract
Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

Objective
Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

Content
Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschafter, vornehmlich zu Themen der Geochemie, Isotogengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

651-1692-00L  Seminar in Applied and Environmental Geophysics  E-  0 credits  1S  H. Maurer, J. Robertson

Abstract
The seminar covers a broad range of topics in environmental and applied geophysics, including environmental geophysics, geophysical methods in environmental monitoring,

Objective
Relations of environment and geophysics. It will focus on the practical use of geophysics in the field of environmental science and engineering.

Content
The seminar covers a broad range of topics in environmental and applied geophysics, including environmental geophysics, geophysical methods in environmental monitoring,

Lecture notes
A list of relevant literature is available on Moodle

651-1694-00L  Seminar in Seismology  E-  0 credits  1S  S. Wiemer, D. Fäh, D. Giardini

Abstract
Short seminars on a variety of popular topics in Seismology. The seminars present current problems and research activities in the seismological community.

Objective
Understanding of a broad scope of current problems and state-of-the-art practice in seismology.

101-0317-00L  Tunnelling I  W  3 credits  2G  G. Anagnostou, A. Nordas, E. Pimentel

Abstract
Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement); Numerical analysis methods.

Objective
Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement); Numerical analysis methods.

Content
Numerical analysis methods in tunnelling. Conventional excavation methods (full face, top heading and bench, side drift method, ...)

Auxiliary measures:
- Jäckings
- Jet grouting
- Ground freezing
- Drainage
- Forepoling
- Face reinforcement

Lecture notes
Autographieblätter

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making

651-1091-00L  Colloquium Department Earth Sciences  E- Dr  0 credits  1K  T. I. Eglinton, C. Magnabosco

Abstract
Invited speakers from the entire range of Earth Sciences.

Objective
Selected themes in sedimentology, tectonics, palaeontology, geophysics, geochemistry, mineralogy, paleoclimate and engineering geology on a regional and global scale.

Content
According to variable program.

Lecture notes
No

651-2613-00L  Human Geography III (Geographies of Difference)  W  5 credits  1G+2S  University lecturers

No enrolment to this course at ETH Zurich. Book the
corresponding module directly at UZH as an incoming student.
UZH Module Code: GEO232

Recommended prerequisite: Human Geography II (UZH Module Code: GEO122)

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit</th>
<th>Lectures</th>
<th>University lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-2601-00L</td>
<td>Human Geography I: One Earth - Many Worlds (University of Zurich)</td>
<td>W</td>
<td>5 credits</td>
<td>2V+2U</td>
</tr>
<tr>
<td>651-4088-03L</td>
<td>Physical Geography III (Geomorphology and Glaciology) (University of Zurich)</td>
<td>W</td>
<td>5 credits</td>
<td>1V+1U</td>
</tr>
<tr>
<td>651-1617-00L</td>
<td>Geophysical Fluid Dynamics and Numerical Modelling</td>
<td>E</td>
<td>0 credits</td>
<td>1S</td>
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<tr>
<td>651-4931-00L</td>
<td>Seminar I: Heat and Mass Transfers in Magmatology</td>
<td>W Dr</td>
<td>1 credit</td>
<td>1S</td>
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<tr>
<td>651-1091-02L</td>
<td>Geological Colloquium</td>
<td>E Dr</td>
<td>0 credits</td>
<td>2K</td>
</tr>
</tbody>
</table>

Abstract

This re-search-oriented course enables students to think through and about difference in a geographically (multi-scalar, critical, space-bound) manner, by elaborating on multiple concepts from postcolonial, intersectional and other disciplinary debates, and by applying these to specific topical domains.

Objective

Knowledge
- Understand basic concepts and empirical manifestations of difference in human geography
- Deepen knowledge on how difference works in one specific topic of human geography

Skills
- Learn to independently digest, assess, and present basic academic texts
- Conduct discussions in English or German (online and offline) - Be able to write a short research paper about a human geography topic

Content

(1) Society and space (2) Society and development (structure and dynamic of population, urbanisation, disparities (3) Society and natural environment (natural resources; food security, sustainability))

651-2601-00L: Human Geography I: One Earth - Many Worlds (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: GEO112

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

Imparting of research questions and basic principles in Human Geography

Objective

To get an overview about basic research questions and principles of Human Geography

Content

(1) Society and space (2) Society and development (structure and dynamic of population, urbanisation, disparities (3) Society and natural environment (natural resources; food security, sustainability))

Lecture notes

PowerPoint-slides (German)

Literature


651-4088-03L: Physical Geography III (Geomorphology and Glaciology) (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: GEO231

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufs. Dabei werden einzelne Wasserspeicher (Schnee-, Boden und Grundwasser) und Flüsse zwischen den Speichern ( Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

651-1091-02L: Geological Colloquium

Invited speakers from the entire range of Earth Sciences.

Selected themes in sedimentology, tectonics, palaeontology, geophysics, mineralogy, paleoclimate and engineering geology on a regional and global scale.

Content

According to variable program.
<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Credits</th>
<th>Prerequisites / Notice</th>
</tr>
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<tbody>
<tr>
<td>651-3280-00L</td>
<td>Earth Science Excursions</td>
<td>W</td>
<td>1</td>
<td>I. Stössel</td>
</tr>
<tr>
<td></td>
<td>Only for MSc and doctorate students of D-ERDW. Only for excursions that are not part of the BSc excursion program 2.-6. semester.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>With the registration for an excursion or a field course students acknowledge having read and understood the General Terms and Conditions for Field Trips and Excursions <a href="https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/studium/exkursionen/AGB_ERDW_Exkursionen_en.pdf">https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/dokumente/studium/exkursionen/AGB_ERDW_Exkursionen_en.pdf</a></td>
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<tr>
<td>651-2001-00L</td>
<td>Semester Research Project (small)</td>
<td>W</td>
<td>3</td>
<td>Lecturers</td>
</tr>
<tr>
<td></td>
<td>Small individual research project supervised by a lecturer of D-ERDW that builds on the skills acquired during the BSc or MSc studies. The project consists of research activity aimed at producing new scientific results and/or data.</td>
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<td></td>
<td></td>
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<tr>
<td>651-4191-00L</td>
<td>Radionuclides as Environmental Tracers</td>
<td>W</td>
<td>3</td>
<td>N. Casacuberta Arola</td>
</tr>
<tr>
<td></td>
<td>Does not take this semester.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Radionuclides stemming from natural and artificial sources are powerful tools that allow gaining a better understanding of a large range of environmental processes. This course will focus on cosmogenic and anthropogenic radionuclides and will provide a general overview about common applications and the use of tracers in the environment, e.g. to understand past climatic changes and ocean currents.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>651-4105-00L</td>
<td>Paleomagnetism</td>
<td>W</td>
<td>3</td>
<td>2G</td>
</tr>
<tr>
<td></td>
<td>Does not take this semester.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Block course takes place again in HS 2023</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>This course focuses on the Earth's magnetic field and the magnetization recorded in rocks as a way to study its past. In addition to mineral magnetism, field and laboratory methods, and data analysis are covered, as well as the wide range of applications of magnetic methods in Earth sciences, e.g. magnetostratigraphy, studies of the early Earth, geodynamics or structural and tectonic studies.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>651-4906-00L</td>
<td>Radiocarbon Dating</td>
<td>W</td>
<td>2</td>
<td>4P</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 6. Please contact the lecturer for details immediately after subscription.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Radiocarbon (14C) dating is the most eminent dating tool for carbon containing samples younger than ~50 kyr and a useful tracer of the carbon cycle. Within this lab course, the sample preparation and 14C analysis of wood samples (or upon agreement other samples) will be performed.</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
In this hands-on block course, students will have the opportunity to perform radiocarbon analysis of wood samples. This will include understanding the theoretical background of radiocarbon dating and its importance within Earth Sciences and related fields. Participants will gain know-how on the preparation of wood samples for AMS analysis. They will learn about the importance of suitable reference materials when performing AMS analysis. Data evaluation for C-14 measurements will be performed and discussed.

**Objective**

Students deepen their knowledge in a specific topic. They familiarize with research procedures and scientific methods that are used in practical applications, and computational methods are covered. The course has a particular focus on solid Earth applications.

**Content**

- Griffith's criterion: stress concentrators, singularities, crack in uniform tension.
- Sampling of tree ring layers.
- Shear cracks: stationary crack tip fields, stress intensity factor, cohesive zone model, quasistatic planar cracks, shear cracks governed by rate-and-state friction.
- 5 Additional: dynamic (inertial) effects, fracture and breakdown energy, coupling between elastodynamics and shear heating, computational methods in fracture mechanics

**Prerequisites / notice**

For decades, researchers have attempted to reconstruct Precambrian environmental states and their relative timing using tracers recorded in the sedimentological, fossil, and genetic records. Here, by reading and discussing “classic” and more recently published scientific papers, students will learn about influential discoveries related to Earth history within the fields of geobiology and geochemistry.

In completing the course, students will specifically learn:

* How to discern between biologic innovation and environmental importance
* How to summarize, interpret, and discuss current evidence for what is and isn't known about Earth’s geochemical and geological evolution
* How to assess opposing scientific viewpoints and outstanding questions in the literature
* The importance of geological, chemical, and biological feedback mechanisms
* Why Earth’s surface chemical composition evolved from anoxic to oxic environments
* How life evolved from simple prokaryotic metabolisms to multicellular eukaryotes

**Science in Perspective**

- How to assess opposing scientific viewpoints and outstanding questions in the literature
- How to assess the relative timing and evolution of biogeochemical cycles
- The importance of geological, chemical, and biological feedback mechanisms
- How life evolved from simple prokaryotic metabolisms to multicellular eukaryotes
- Why Earth’s surface chemical composition evolved from anoxic to oxic environments

**Literature**

All required and recommended scientific publications will be provided online during the course.

**Lecture notes**

Where available, presentations and notes will be provided online during the course.

**Prerequisites / notice**

This is a block course for D-ERDW or D-USYS master or PhD students.

Recommended (but not a prerequisite) 651-4191-00L Radionuclides as Environmental Tracers (in Autumn Semester)

OR

651-4901-00L Quaternary Dating Methods (in Autumn Semester)
Abstract
The main purpose of the Master Project Proposal is to help students organize ideas, material and objectives for their Master Thesis, and to begin development of communication skills.

Objective
The main objectives of the Master Project Proposal are to demonstrate the following abilities:
- to formulate a scientific question
- to present scientific approach to solve the problem
- to interpret, discuss and communicate scientific results in written form
- to gain experience in writing a scientific proposal

<table>
<thead>
<tr>
<th>Master's Thesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
</tr>
<tr>
<td>651-4062-00L</td>
</tr>
</tbody>
</table>

Abstract
The master programme will be completed by a master thesis on a topic selected from the subject range of the chosen major programme. Students are to prove their skills in working autonomously on a scientific project.

Objective
Students are to prove their skills in working autonomously on a scientific project. They document their work in a scientific report.

<table>
<thead>
<tr>
<th>Course Units for Additional Admission Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>The courses below are only available for MSc students with additional admission requirements.</td>
</tr>
<tr>
<td>Number</td>
</tr>
<tr>
<td>651-3070-AAL</td>
</tr>
<tr>
<td>651-3400-AAL</td>
</tr>
</tbody>
</table>

Abstract
Self-study course. This course is only available for those who got it as an additional requirement in their MSc admission.

Objective
The course is intended to let the student learn fundamentals of geochemistry that were found lacking in his/her studies prior to entering the MSc in Earth Sciences at ETH. Contents of the course will be defined based on textbook and/or scientific papers.

<table>
<thead>
<tr>
<th>Analysis I and II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
</tr>
<tr>
<td>406-0243-AAL</td>
</tr>
</tbody>
</table>

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers.

Content

Literature
Textbooks in English:

Textbooks in German:
- M. Akveld, R. Sperl: Analysis I, vdf
- M. Akveld, R. Sperl: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

<table>
<thead>
<tr>
<th>Physics I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
</tr>
<tr>
<td>406-0062-AAL</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.
Objective

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter. The student should acquire an overview over the basic concepts in mechanics.

Content

Book:

Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature
see "Content"

651-3521-AAL Tectonics

T. Gerya, W. Behr

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract

Comprehensive understanding of role and evolution of oceanic and continental lithosphere in global plate tectonics and evolution of earth.

Objective

Comprehensive understanding of role and evolution of oceanic and continental lithosphere in global plate tectonics and evolution of earth.

Content


Lecture notes
Detailed scriptum in digital form and additional learning moduls (www.lead.ethz.ch) available on intranet.

Literature
see list in scriptum.

Prerequisites / notice
PPT-files of each lecture may be played back for rehearsal on www.lead.ethz.ch.

529-2001-AAL Chemistry I and II

J. Cvengros

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract

General Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

Objective

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content

1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature
Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management assessed
Stochastics (Probability and Statistics)  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student’s t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
From within the ETH, this book is freely available online under:

From within the ETH, this book is freely available online under:
http://www.springerlink.com/content/m17578/

Introduction to Engineering Geology  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This introductory course starts from descriptions of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

Objective
Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

Content

Lecture notes
Lecture Material as defined in German PPT Slides of the German Course "651-3525-00L Ingenieurgeologie". Moodle Course Materials available.

Literature
For English speakers study chapters 1-3 of Part I of the book “Geological Engineering” (Gonzalez de Vallejo & Ferrer 2011, CRC Press), without groundwater flow, consolidation time, geophysical methods, details of triaxial tests in soils and rocks, details of clay mineralogy.

Prerequisites / notice
Participate on all exercises of “651-3525-00L Ingenieurgeologie”, Tuesday 13-14 pm.
Participate in Written Exam together with students of the German Course

Earth Sciences Master - Key for Type

<table>
<thead>
<tr>
<th></th>
<th>Compulsory</th>
<th>W+</th>
<th>W</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td></td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th></th>
<th>lecture</th>
<th>lecture with exercise</th>
<th>exercise</th>
<th>seminar</th>
<th>colloquium</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td></td>
<td>P practical/laboratory course</td>
<td></td>
<td>A independent project</td>
<td>D diploma thesis</td>
</tr>
<tr>
<td>U</td>
<td></td>
<td>R revision course / private study</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Mathematics Education Master

## Courses Offered

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**
This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

- Thematische Schwerpunkte: Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen.

- Lecture notes: Folien werden zur Verfügung gestellt.


**Prerequisites / notice**
This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma" or "Teaching Certificate". It is about learning in childhood and adolescence.

## Support and Diagnosis of Knowledge Acquisition Processes (EW3)

**Abstract**
In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**
The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

**Mathematics Education Master - Key for Type**

<table>
<thead>
<tr>
<th>W</th>
<th>Eligible for credits</th>
<th>Z</th>
<th>Courses outside the curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Science Education Master

Eduational Science (for all Directions)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

Thematische Schwerpunkte:
- Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:

**Lecture notes / Literature**

Folien werden zur Verfügung gestellt.

Literature:

**Prerequisites / notice**

This course is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

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### Biological Direction

#### Specialised Courses

#### Introductory Courses

#### Spec. Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0238-01L</td>
<td>Support and Diagnosis of Knowledge Acquisition Processes (EW3)</td>
<td>W</td>
<td>3</td>
<td>3S</td>
<td>C. M. Thurn, S. Daguati, P. Edelsbrunner</td>
</tr>
</tbody>
</table>

**Abstract**

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**

The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students’ misconceptions.

---

**Support and Diagnosis of Knowledge Acquisition Processes (EW3)**

Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the "Teaching Diploma".

**Prerequisites**: successful participation in 851-0240-00L "Human Learning (EW1)".

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### Spec. Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0973-00L</td>
<td>Specialized Biology Course with an Educational Focus: Evolution</td>
<td>W</td>
<td>6</td>
<td>2G+13A</td>
<td>H. Stocker, Y. Barral, K. Köhler</td>
</tr>
</tbody>
</table>

**Abstract**

Specialist aspects of biology with a focus on evolution are covered from the angle of imparting these to pupils, their historical development, and their significance for the subject, the individual and society.

**Objective**

After successful completion of the module, students should be able
- to retrieve in-depth knowledge of biology with a special focus on evolution and to impart this to others.
- to analyse controversial topics and to give factual explanations for these.
- to conduct more in-depth work on a research topic and to compile a tuition unit based on this topic
- to prepare tuition units involving complex learning matter at a high specialist level which are suitably tailored to the recipients, and to teach these in a manner conducive to learning.

**Content**

Selected biological topics, with a special focus on evolution, are dealt with under consideration of the special needs of persons involved in teaching. The module comprises lectures, a book club, and a seminar thesis.

**Lecture notes / Literature**

Teaching materials are available online on Moodle.

Literature and references are posted online on Moodle.

**Prerequisites / notice**

The Specialized Biology Course with an Educational Focus consists of two modules (6 CP each). In the fall semester, the focus is on evolution. The module of the spring semester deals with biological concepts. Students attending both modules can start with either module.

Performance is assessed during the course of the entire module. Active participation in the course is required. The thesis (including oral presentation) has to be completed.

The Specialized Biology Course with an Educational Focus (6+6 CP) can be acknowledged, in agreement with the advisor of the respective elective major, as one of the two obligatory research projects (each 15 CP). In such a case, additional 3 CP must be obtained in another course.

In case of overbooking of the course, students enrolled in the Teaching Diploma in Biology will have priority.
### Subject Didactics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0913-00L</td>
<td>Professional Exercises in Biology</td>
<td>W</td>
<td>2</td>
<td>2U</td>
<td>P. Faller</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students conduct a series of “classical” biological school experiments and therefore gain practice and experience in this area. Implementation of Subject Didactics I and II with the focus on conducting biological experiments in schools. This includes finding, testing and further developing suitable protocols for different subject areas of school biology. Working out how to didactically embed the experiments in lessons. Students can perform, off the cuff, 12 school experiments (which they have tested themselves), from the different subject areas, and conduct these correctly in technical terms. They can incorporate these experiments in their tuition in a didactically meaningful manner. Comments: By contrast to the Subject Specialisation 1 and 2 course units, these are “basic tests” and do not involve the implementation of current research topics. The students’ compilations are available in a data archive.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Hand out of course material.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Der Teil biologische Experimente findet im Rahmen von 7 Halbtagen statt.</td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Subject Didactics Biology I</th>
<th>W</th>
<th>4</th>
<th>3G</th>
<th>P. Faller</th>
</tr>
</thead>
</table>
| Abstract     | Simultaneous enrolment in Introductory Internship Biology  
- Basic conditions for tuition (MAR - recognition of Matura certificates - curricula, standards), selection of topics and reduction of the complexity of topics.  
- Application of teaching methods and techniques from educational science in biology classes.  
- Planning and preparation of lessons.  
- Students can discuss and put into practice in their teaching work the conditions and objectives set out in the regulations governing the school-leaving examination (Matura), the framework curriculum and the conditions and objectives specified by their school.  
- They are in a position to select learning objectives and formulate these on the basis of the target level model. They can plan and prepare lessons and can also develop appropriate learning assignments.  
- Students can reconstruct specialist contents in didactic terms and develop teaching modules suitable for the different levels from these on the basis of the subject structure and learner requirements.  
- They can reduce the complexity of subject-based specialist contents and present them in such a way that they are comprehensible and meaningful for learners.  
- They can select appropriate media for their work (e.g. school books) and use these. They can employ appropriate experiments.  
- The students can use different forms of examination for monitoring performance.  
- Students are in a position to implement and discuss the concepts of biology teaching and learning on the basis of specific topics covered in school biology. |
| Objective    |                                                                 |      |      |       |           |
| Lecture notes| Wird laufend in der Vorlesung abgegeben. |
| Prerequisites / notice | Studierende müssen LE zusammen mit dem Einführungspraktikum - LE 551-0968-00L - belegen. |

<table>
<thead>
<tr>
<th>Number</th>
<th>Teaching Science in Higher Education</th>
<th>W</th>
<th>3</th>
<th>1V</th>
<th>G. Schilt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context. Students are able to characterize and to discuss the model of outcomes based education. Students are able to transfer the basic concepts of this model (ILO, TLA, assessment, constructive alignment) to science education.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Lecture notes</td>
<td>keines</td>
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</tr>
</tbody>
</table>
| Taught competencies | Subject-specific Competencies  
- Concepts and Theories  
- Techniques and Technologies  
Method-specific Competencies  
- Analytical Competencies  
- Decision-making  
- Problem-solving  
Social Competencies  
- Communication  
- Customer Orientation  
- Leadership and Responsibility  
- Self-presentation and Social Influence  
- Sensitivity to Diversity  
Personal Competencies  
- Adaptability and Flexibility  
- Creative Thinking  
- Critical Thinking  
- Self-awareness and Self-reflection  
- Self-direction and Self-management |

### Specialised Courses

### Introductory Courses

*Selection of courses will be agreed with the course coordinator.*

### Spec. Courses in Respective Subject with Educational Focus
Students are able to characterize and to discuss the model of outcomes based education.

Abstract

Selected topics in general chemistry:
1) The language of chemistry
2) Chirality and stereochimistry
3) Oxidation of water
4) Chemistry of the atmosphere

Objective

In this course, participants acquire extended and more in-depth knowledge of selected chemistry topics. The selection is based to a large extent on the partial aspects of chemistry that are typically taught at high school. By gaining a broader understanding, teachers are put in a position where they can comprehend the topics that are to be taught in a wider and, to some extent, unconventional context and critically process these in respect of their teachability and learnability. At the same time, interrelationships between the classical sub-disciplines of chemistry are highlighted, along with the unique features of chemistry as one of the central natural sciences.

Content

Content of the four modules:
1) The language of chemistry: Concepts, formulas, aesthetics, and philosophical aspects
2) Chirality and stereochimistry: Selected aspects, origin of biomolecular chirality, inorganic chemistry
3) Cosmochemistry
4) Chemistry of the atmosphere

Literature

Folie und ausgewählte Literatur werden zur Verfügung gestellt.

Prerequisites / notice

FV A (gelesen im Frühjahrsemester) und FV B (gelesen im Herbstsemester) bauen nicht aufeinander. Die Reihenfolge der Belegung ist somit indifferent.

Subject Didactics

Abstract

Implementing findings from research into teaching and learning for chemistry lessons and coverage of subject-specific teaching and learning specialities.

Objective

The students have basic subject didactic knowledge for teaching chemistry at a secondary school. They are able to design lessons that are effective for learning, actively involve students in lessons, explain challenging concepts simply, use experiments for theory and reflect on teaching.

Content

Schwerpunkte im ersten Studiensemester bilden die folgenden Themen:
- Auswahl gymnasiumrelevanter Lerninhalte
- Didaktische Vereinfachung
- Modell- und chemischen Formeln zur Beschreibung von Bau auf und Umwandlung der Substanzen
- Wechselspiel zwischen Beobachtung in der realen Welt und Deutung auf Modell-Ebene
- Skizzen entwerfen und zur Erklärung von Reaktionen nutzen
- Chemie im 8. Schuljahr: Das Teilchenmodell erklärt viele Phänomene im Anfangsunterricht
- Atommodelle und chemische Bindung
- Radioaktivität und Kernspaltung
- Struktur und Eigenschaft
- Auswahl, Konzeption, Vorbereitung, Durchführung, Einbettung und Auswertung von Demonstrations-Experimenten

Literature

- E. Rossa: Chemie-Didaktik, Cornelsen Verlag, 2015
- H.-J. Bader et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002

Prerequisites / notice

Die Chemieunterricht am Gymnasium soll einerseits grundlegende chemische Kenntnisse für den Alltag vermitteln und andererseits auf ein naturwissenschaftlich orientiertes Hochschulstudium vorbereiten. Diese beiden Ziele sind im Unterricht gleichermassen zu berücksichtigen.

Anhand der Diskussion bewährter Beispiele und dem Entwurf eigener Unterrichtsbausteine soll die zukünftige Lehrperson befähigt werden, einen den spezifischen Rahmenbedingungen angepassten Unterricht zu entwickeln, der diesem hohen Qualitätsanspruch genügt.

Teaching Science in Higher Education

This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context. Students are able to characterize and to discuss the model of outcomes based education.

Students are able to transfer the basic concepts of this model (ILO, TLA, assessment, constructive alignment) to science education.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module CHE406 at UZH.
Examination Registration only at ETH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

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Examination Registration only at ETH.

Please mind the ETH enrolment deadlines for non-UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Examination Registration only at ETH.
**Taught competencies**

**Subject-specific Competencies**
- Concepts and Theories assessed
- Techniques and Technologies assessed

**Method-specific Competencies**
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

**Social Competencies**
- Communication assessed
- Customer Orientation assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed

**Personal Competencies**
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

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**Physical Direction**

**Specialised Courses**

**Introductory Courses**

**Spec. Courses in Respective Subject with Educational Focus**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
</tbody>
</table>

**Abstract**
Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts.

**Objective**
- Why is energy important for life and our society?
- How did energy use change over time? Which effects did these changes have on the environment?
- What are the physical basics of energy technologies?
- Why, when and how did technology and science of energy come together?
- What are the limits and benefits of all the various energy technologies?
- How can different energy technologies be compared?
- Can we understand the changes in the current energy systems?
- How will the energy systems of the future look like?
- How fast can we and should we enforce the current energy transition?
- Which could be the overall guidelines for a working energy system of the future?

**Content**
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

**Literature**
The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014
Energy and Civilization: A History, V. Smil, 2018
Renewable Energy – Without the Hot Air, D.J.C. Mackay 2009

**Prerequisites / notice**
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

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**Subject Didactics**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0910-00L</td>
<td>Physics Didactics I: Special Didactics of Physics Teaching ■</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Mohr</td>
</tr>
</tbody>
</table>

*Limited number of participants.*

*Further information is available from the lecturer via email: mamohr@ethz.ch*

*Simultaneous enrolment in Introductory Internship Physics - course 402-0920-00L - is compulsory for Teaching Diploma Physic*
Die Studierenden verfügen über fachdidaktisches Grundwissen für den Physikunterricht an einer Mittelschule. Sie können eigene Lektionen unter Berücksichtigung der vielfältigen Rahmenbedingungen planen, durchführen und evaluiieren. Sie reflektieren ihren Unterricht und sind bestrebt, ihn didaktisch und pädagogisch weiter zu entwickeln.

Die Studierenden kennen die Einsatzmöglichkeiten, Chancen und Schwierigkeiten verschiedener Unterrichtsmethoden und Hilfsmittel. Sie können die Eignung von Unterrichtsformen im Hinblick auf einen Lernsituation beurteilen. Sie bemühen sich in ihrem Unterricht, geeignete Methoden und Medien angepasst an die Klasse und das Thema einzusetzen.


### Natural Sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-3001-00L</td>
<td>Dynamic Earth I</td>
<td>W</td>
<td>6</td>
<td>4V+2U</td>
<td>O. Bachmann, A. Galli, A. Fichtner, M. Schönbächler, S. Willett</td>
</tr>
</tbody>
</table>

**Abstract**

Provides a basic introduction into Earth Sciences, emphasizing different rock-types and the geological rock-cycle, as well as introduction into geophysics and plate tectonic theory.

**Objective**

Understanding basic geological and geophysical processes

**Content**

Overview of the Earth as a system, with emphasis on plate tectonic theory and the geological rock-cycle. Provides a basic introduction to crystals and minerals and different rock-types. Lectures include processes in the Earth's interior, physics of the earth, planetology, introduction to magmatic, metamorphic and sedimentary rocks. Exercises are conducted in small groups to provide more in depth understanding of concepts and content of the lectures.

**Lecture notes**

werden abgegeben.

**Literature**


**Prerequisites / notice**

Exercises and short excursions in small groups (10-15 students) will be lead by student assistants. Specific topics in earth sciences will be discussed using examples and case studies. Hand samples of the major rock types will be described and interpreted. Short excursions in the region of Zurich will permit direct experience with earth science processes (e.g. earth surface processes) and recognition of earth science problems and solutions relevant for modern society (e.g. building materials, water resources). Working in small groups will allow for discussion and examination of actual earth science themes.
<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects ■ W Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Schumacher</td>
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<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<td></td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td>- Get information about recent literature on learning and instruction</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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<tr>
<td>851-0242-07L</td>
<td>Human Intelligence ■ W Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). Number of participants limited to 30.</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>E. Stern</td>
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<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<td><strong>Abstract</strong></td>
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<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<td></td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td>- Getting to know intelligence tests</td>
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<td></td>
<td>- Understanding findings relevant for education</td>
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<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science ■ W Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). Number of participants limited to 30.</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>C. M. Thurn, T. Braas, P. Edelsbrunner</td>
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<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>- Understand research methods used in the empirical educational sciences</td>
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<td>- Understand and critically examine information from scientific journals and media</td>
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<td>- Understand pedagogically relevant findings from the empirical educational sciences</td>
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<tr>
<td>851-0242-11L</td>
<td>Gender Issues In Education and STEM ■ W Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>M. Berkowitz Biran, T. Braas, C. M. Thurn</td>
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<td></td>
<td>Number of participants limited to 30.</td>
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<td><strong>Abstract</strong></td>
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<td>In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues</td>
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<td>- To develop a critical view on existing research and perspectives.</td>
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<td>- To integrate this knowledge with teacher’s work.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.</td>
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<td>The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td></td>
<td>Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).</td>
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<tr>
<td>851-0229-00L</td>
<td>Using Outdoor Education ■ W Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>R. Schumacher, P. Faller</td>
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<tr>
<td></td>
<td>Number of participants limited to 40.</td>
<td></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.</td>
<td></td>
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</tbody>
</table>
Objective
Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Content
Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

Subject Didactics in Geography

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4239-00L</td>
<td>Subject Didactics Geography I (University of Zurich)</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UZH Module Code: 090GG1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited number of participants.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In addition to the course enrollment a registration by email is required to Dr. Stefan Hesske (E-Mail: <a href="mailto:stefan.hesske@ife.uzh.ch">stefan.hesske@ife.uzh.ch</a>).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mind the enrolment deadlines at UZH <a href="https://www.uzh.ch/cmsssl/en/studies/application/deaselines.html">https://www.uzh.ch/cmsssl/en/studies/application/deaselines.html</a></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Abstract
Fundamentals (theory and practice) of specialist subject teaching for high-school geography lessons.

Prerequisites / notice
A maximum of 12 CP additional requirements in Geography may be open before registering for the didactics Geography.

Please provide the form https://ethz.ch/content/dam/ethz/main/education/didaktische-ausbildung/files/diverses/form_auflagen_bis%2012%20kp_291015.pdf as a confirmation.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4124-00L</td>
<td>Examination Subject Didactics</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>S. Hesske, J. Rafflenbeul</td>
</tr>
</tbody>
</table>

Abstract
Die Prüfung Fachdidaktik bildet den Abschluss der didaktischen Ausbildung und wird nach erfolgreichem Abschluss aller Ausbil dungsbereiche der didaktischen Ausbildung abgelegt.

Content
Geprüft werden:
- Fähigkeit, Geografie-Unterricht mit Bezug zur eigenen Praxis kritisch und unter verschiedenen Blickwinkeln (inhaltlich, methodisch-didaktisch) zu betrachten, Lernarrangements mit Bezug zum heutigen Bildungs- und Schulfachverständnis zu gestalten und kritisch zu hinterfragen sowie deren möglichen erzielten Wirkungen zu diskutieren und zu begründen; Unterrichtssituationen zu reflektieren und zu evaluieren.

Lecture notes
Unterlagen aus der fachdidaktischen Ausbildung

Literature

Prerequisites / notice
The examination lessons I and II must be enrolled and completed together with the examination didactics.

The examination didactics is an 15-minutes oral exam that takes place at the same day together with the examination lessons I and II.

Taugte competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving not assessed
- Project Management not assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management not assessed

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4120-00L</td>
<td>Subject Didactics Geography IV: Mentored Project</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>S. Hesske, J. Rafflenbeul</td>
</tr>
</tbody>
</table>

Abstract
Mentorierte Arbeit mit Bezug zur fachdidaktischen Ausbildung.

Objective
selbständige, theoriegestützte Auseinandersetzung mit konkreter, praxisbezogener Fragestellung zum Geographieunterricht.

Content
selbständige, mentorierte Arbeit zu einem Thema aus der Fachdidaktik mit direktem Bezug zur Lehrpraxis im Fach Geografie (z.B. zu eigenen Übungenlektionen und Praktikum oder zur Unterrichtsforschung).

Literature

Prerequisites / notice
May be completed together with didactics III at the earliest.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Method-specific Competencies
- Media and Digital Technologies: assessed
- Problem-solving: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

651-4118-00L Subject Didactics Geography III (University of Zurich)

- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- UZH Module Code: 090GG3
- Limited number of participants. In addition to the course enrolment a registration by email is required no later than September 1 for autumn semester, February 1 for spring semester. Further details see UZH module.
- Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
Working with medias in Geography teaching:

Prerequisites / notice
Geography Didactics III may be completed in parallel with Geography Didactics II, but only after successful completion of Geography Didactics I.

651-4119-00L Introductory Internship (University of Zürich)

- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- UZH Module Code: 090BPEP
- Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
The Introductory Internship belongs to the practical expertise education of the teacher training for Upper Secondary Schools and must be completed at the beginning of studies.

Prerequisites / notice
The Introductory Internship must be completed together with the practice lessons for didactics.

The Introductory Internship can only be completed together with an accredited internship teacher of ETH Zurich (separate list).

651-2519-02L Practice Lessons for Subject Didactics (University of Zürich)

- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- UZH Module Code: 090BPUE
- Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
The practice lessons help students to gain first experiences in teaching and is completed together with the didactics courses.

Prerequisites / notice
The practice lessons for didactics must be completed within the didactic courses.

Students register for the module at UZH ideally together with didactics II. ECTS will be assigned after having handed in all relevant documents to the lecturers, at the earliest upon completion of didactics II.

The Practice Lessons can only be completed together with an accredited internship teacher of ETH Zurich (separate list).

651-2517-00L Teaching Internship I Geography (University of Zürich)

- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

Professional Training in Geography

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Number Title Type ECTS Hours Lecturers
651-4118-00L Subject Didactics Geography III (University of Zurich) O 3 credits 2G University lecturers
651-2519-01L Introductory Internship (University of Zürich) O 1 credit 2P University lecturers
651-2519-02L Practice Lessons for Subject Didactics (University of Zürich) O 2 credits 4P University lecturers
651-2517-00L Teaching Internship I Geography (University of Zürich) O 8 credits 17P University lecturers

Reflexion des Kandidaten/ der Kandidatin über die gehaltene Lektion im Rahmen eines Kolloquiums (15 min).

Die gehaltene Lektion wird kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/ der Kandidatin über die gehaltene Lektion im Rahmen eines Kolloquiums (15 min).

Prerequisites: Successful completion of Educational Science and Subject Didactics in Geography (FD I, II, III) as well as Spec. Courses in Resp. Subj. w/ Educ. Focus & Further Subj. Didactics (FV I, II, III) plus completion of the introductory internship.

The Introductory Internship can only be completed together with an accredited internship teacher of ETH Zurich (separate list).

**651-2520-01L** Examination Lesson I Geography

To be completed together with Examination Lesson II 651-2520-02.

| Abstract | In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training. |
| Objective | On the basis of a specified topic, the candidate shows that they are in a position |
| Content | - to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle |
| Lecture notes | Dokument: Schriftliche Vorbereitung für Prüfungslektionen. |
| Prerequisites / notice | Takes place at the end of the studies, prerequisites: successful completion of the program. |

The examination lessons I and II must be enrolled and completed together with the examination didactics.

**651-2520-02L** Examination Lesson II Geography

To be completed together with Examination Lesson I 651-2520-01.

| Abstract | In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training. |
| Objective | On the basis of a specified topic, the candidate shows that they are in a position |
| Content | - to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle |
| Lecture notes | Dokument: Schriftliche Vorbereitung für Prüfungslektionen. |
| Prerequisites / notice | Takes place at the end of the studies, prerequisites: successful completion of the program. |

The examination lessons I and II must be enrolled and completed together with the examination didactics.

**651-4137-00L** Semester Paper Within the 1st Teaching Internship Geography (University of Zurich)

*No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*

UZH Module Code: 090BPP1

Mind the enrolment deadlines at UZH:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-2517-02L</td>
<td>Teaching Internship II-E Geography (University of Zurich)</td>
<td>O</td>
<td>6 credits</td>
<td>13P</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

An additional registration at LLBM is needed for further details refer to the module of UZH.

Mind the enrolment deadlines at UZH:
The teaching internship II has to be completed after the teaching internship I at the end of the program in the same semester. Prerequisite is the successful completion of all courses of the teaching diploma program.

The internship can only be completed together with an accredited internship teacher of ETH Zurich (separate list).

**Compulsory Elective Courses**

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>851-0229-00L</td>
<td>Using Outdoor Education</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>R. Schumacher, P. Faller</td>
</tr>
<tr>
<td>860-0023-00L</td>
<td>International Environmental Politics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>T. Bernauer</td>
</tr>
</tbody>
</table>

**Additional Requirements (ETH-Masterstudents in ERDW and AC)**

**Part 1**

**Compulsory Modules**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-2601-00L</td>
<td>Human Geography I: One Earth - Many Worlds</td>
<td>O</td>
<td>5</td>
<td>2V+2U</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO112

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

**Abstract**
Imparting of research questions and basic principles in Human Geography

**Objective**
To get an overview about basic research questions and principles of Human Geography

**Content**
(1) Society and space (2) Society and development (structure and dynamic of population, urbanisation, disparities) (3) Society and natural environment (natural resources; food security, sustainability)

**Lecture notes**
PowerPoint-slides (German)

**Literature**

---

**Human Geography III (Geographies of Difference)**

(University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO232

Recommended prerequisite: Human Geography II (UZH Module Code: GEO122)

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

**Abstract**
This research-oriented course enables students to think through and about difference in a geographically (multi-scalar, critical, space-bound) manner, by elaborating on multiple concepts from postcolonial, intersectional and other disciplinary debates, and by applying these to specific topical domains.

**Objective**

- Understand basic concepts and empirical manifestations of difference in human geography
- Deepen knowledge on how difference works in one specific topic of human geography

**Skills**
- Learn to independently digest, assess, and present basic academic texts
- Conduct discussions in English or German (online and offline)
- Be able to write a short research paper about a human geography topic

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### Modules of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>651-2603-00L</td>
<td>Geography. Matters. (University of Zurich)</td>
</tr>
</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO410

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

**Abstract**
The course demonstrates geography's interdisciplinary approach to contribute solving urgent challenges ahead of society. Students are encouraged to reflect on the value of interdisciplinary research at discipline level and on their individual interdisciplinary curricula. The course creates awareness of ways that concepts structure our thinking, and how they figure in research and practice.

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### Part 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>651-4088-03L</td>
<td>Physical Geography III (Geomorphology and Glaciology) (University of Zürich)</td>
</tr>
</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO231

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

**Abstract**
Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufes. Dabei werden einzelne Wasserspeicher (Schnee-, Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

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### Part 3

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>651-2338-00L</td>
<td>Remote Sensing and Geographic Information Science III (University of Zürich)</td>
</tr>
</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO233

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

---
Exercises to the course Introduction Remote Sensing.

103-0214-00L

**Cartography Fundamentals**

W 5 credits 4G L. Hurni

**Abstract**

Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

**Objective**

Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

**Content**

Definitions "map" and "cartography", map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critics.

**Lecture notes**

Will be distributed module by module.

**Literature**


**Prerequisites / notice**

Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Customer Orientation</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**Geography Teaching Diploma - Key for Type**

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
After this course, the students should be able to:

- describe the most important established national and international spatial and temporal reference systems;
- describe the techniques, processes, and institutions needed to establish and maintain reference frames;
- select appropriate reference systems and frames for specific geospatial modeling/analysis tasks;
- carry out coordinate transformations, conversions, and time operations on geospatial data, taking into account and quantifying the uncertainties;
- combine geospatial data originally referring to different reference frames into a single reference frame.

This course supports the students in acquiring an in-depth understanding of sensors, sensor systems and sensor networks for the acquisition of geospatial data. Emphasis is put on the prediction and assurance of data quality based on an understanding of key sensing principles, external influences, and data acquisition processes.

The course introduces basic methods of geostatistics and geospatial data analysis. Topics include spatial correlation, auto-correlation and the variogram; surface interpolation (kernel-based, kriging, parametric surface models); spatially adaptive filtering (bilinear, guided filter); spatial stochastic processes and random fields; time series models and spatio-temporal analysis.

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Objective

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
- general introduction of transport, modes, technologies,
- system design and line planning for different situations,
- mathematical models for design and line planning
- timetabling and tactical planning, and related mathematical approaches
- operations, and quantitative support to operational problems,
- evaluation of public transport systems.

Content

Basics for line transport systems and networks
- Passenger/Supply requirements for line operations
- Objectives of system and network planning, from different perspectives and users, design dilemmas
- Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
- Planning process, from demand evaluation to line planning to timetables to operations
- Matching demand and modes
- Line planning techniques
- Timetabling principles
- Allocation of resources
- Management of operations
- Measures of realized operations
- Improvements of existing services

Lecture notes

Lecture slides are provided.

Literature

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)


Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

103-0337-00L Site and Project Development

W 3 credits 2G A. Gonzalez Martinez

Abstract

The focus of the lecture Site & Project Development is on larger contiguous areas or sites and their urban, open space and infrastructural development. In this course, students work on a semester exercise in which they “develop” a specific large-scale project from practice and evaluate it economically, strategically and in terms of feasibility.
Objective

Students in this course will pursue the following learning objectives:

- Investigate and understand a given concrete project area and identify, evaluate and articulate the current problems and relevant issues within this area.

- Consolidate their knowledge in the essential topics of site & project development and apply this in a well-founded, argued and creative manner to address the task at hand.

- Organize and structure themselves while acquiring responsibilities in their interdisciplinary project teams. The teams consist of three to five fellow students that must develop innovative, viable and resilient concepts for a real project development in a given area. Their considerations should be presented in written form (project report) and in linguistic-visual form (final presentation). At the end of the course, the students critically reflect on their experiences with the group work process together with the course instructors.

- Acquire methodological knowledge in location & market analysis, 3D visualization of a project as well as in the financial assessment of a large-scale real estate project and use this knowledge to justify their considerations and evaluate their proposal.

- Development and strengthening of their individual position as planners (spatial, urban, transport planners, etc.) in relation to the questions formulated in the proposed project within the field of Site & Development as well as within their own discipline.

Content

The lecture is divided into several thematic sections analogous to the essential topics of Site & Project Development. The students are accompanied both in the semester exercise and in the individual lectures by a large number of external guest speakers from the praxis-field, which means that the lecture will not only thematically examine the relevant areas of Site & Project Development, but also will offer the students exclusive, practice-oriented insights. The relevant methodological knowledge for the semester exercise is imparted and, due to the proximity to practice, the students gain exclusive insights into possible professional fields of activity. In this lecture, students apply their already acquired and newly learned skills, especially in interdisciplinary teams, and work on an exciting, motivating and relevant question from the practice.

Major topics covered in the lecture include:
- Urban planning
- Location and market analysis
- Real estate development, financing and valuation
- Project development and decision-making from the perspective of investors
- Open space design and landscape architecture
- Sustainable building and sustainability certification
- Mobility, parking issues, travel models
- Cooperative planning and participation processes, mediation
- Gendered planning in project development
- Inner development & urban quality

Parallel to the lecture series, students work in interdisciplinary teams on a real-life task. In the course of the semester exercise, the lecture material is deepened and what has been learned is applied. The students visit the project area at the beginning of the semester as part of an excursion. Specific large-scale projects such as the Gaswerkareal Bern, the Stihl-Manegg Areal Zurich (Greencity) or the Areal Alter Pilatusmarkt (Nidfeld) Lucerne will be dealt with. For the possible development of the given site, visions are developed by the students on the basis of a comprehensive location and market analysis and a utilization concept is developed. In the process, the students are accompanied both in the semester exercise and in the individual lectures by a large number of external guest speakers from the praxis-field, which means that the lecture will not only thematically examine the relevant areas of Site & Project Development, but also will offer the students exclusive, practice-oriented insights. The relevant methodological knowledge for the semester exercise is imparted and, due to the proximity to practice, the students gain exclusive insights into possible professional fields of activity. In this lecture, students apply their already acquired and newly learned skills, especially in interdisciplinary teams, and work on an exciting, motivating and relevant question from the practice.

Lecture notes

- Handouts of the lectures
- Extracts from relevant scientific articles and theory literature
- Exercise material

Download: https://irl.ethz.ch/de/education/vorlesungen/msc/project_development.html

References in the lecture notes

none

Taught competencies

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<th>Subject-specific Competencies</th>
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Application Development in Cartography

W 6 credits 4G L. Hurni

Objective

This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.
Learn how to apply photogrammetry, image analysis and machine learning to mapping tasks; hands-on experience in implementing.

**Basics and Principles of Radar Remote Sensing for Environmental Applications**

Abstract

The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation.

Objective

The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:

1. SAR basics and principles
2. SAR polarimetry
3. SAR interferometry
4. Environmental parameter estimation from multi-parametric SAR data

Content

The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:

1. SAR basics and principles
2. Introduction into SAR basics and principles
3. Introduction into electromagnetic wave theory
4. Introduction into scattering theory and decomposition techniques
5. Introduction into SAR interferometry
6. Introduction into SAR interferometry
7. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

**Image-based Mapping**

Abstract

Application of photogrammetry and remote sensing methods for mapping and Earth observation.

Objective

Learn how to apply photogrammetry, image analysis and machine learning to mapping tasks; hands-on experience in implementing.

Content

Preprocessing of satellite images, atmospheric correction; extraction of features (radiometric indices, texture descriptors, etc.) from raw image intensities; semantic image segmentation (e.g., cloud masking); physical parameter estimation (e.g., vegetation height); practical deployment of geometric and semantic computer vision and image analysis methods for mapping; assessment of prediction results

**Applied Radar Remote Sensing**

Abstract

This course provides an introduction to processing and interpreting radar and synthetic aperture radar (SAR) remote sensing data. The primary topics of the course are interferometric techniques and related applications such as topography mapping and mapping of surface displacements, with a strong emphasis on solving practical problems using MATLAB.

Objective

Understand the concepts and techniques required to process and to adequately interpret interferometric radar/SAR data for topographic mapping and surface displacement applications.

Content

At the end of the course the student is able to read, display, process, and interpret interferometric radar/SAR data for various applications.

The course starts with the real-aperture radar case and a first introduction to the concept of radar interferometry with applications to topographic mapping and mapping of surface displacements.

Based on that, the 2-D imaging concept used in synthetic aperture radar imaging is treated.

Then, we expand further on radar and SAR interferometric (InSAR) concepts and processing steps for single interferograms and stacks of interferograms also using persistent scatterer interferometry (PSI) to measure deformation based on time series of interferometric SAR data.

Finally, the 3-D radar imaging case (SAR tomography) is put into context with PSI/InSAR time series as an extension of the more classical interferometric approaches thereby closing the circle around the strongly related concepts of SAR imaging and interferometry.

**Image-based Mapping**

Abstract

Application of photogrammetry and remote sensing methods for mapping and Earth observation.

Objective

Learn how to apply photogrammetry, image analysis and machine learning to mapping tasks; hands-on experience in implementing automatic image analysis methods, and in judging their results.

Content

Preprocessing of satellite images, atmospheric correction; extraction of features (radiometric indices, texture descriptors, etc.) from raw image intensities; semantic image segmentation (e.g., cloud masking); physical parameter estimation (e.g., vegetation height); practical deployment of geometric and semantic computer vision and image analysis methods for mapping; assessment of prediction results

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Understand the concepts and techniques required to process and to adequately interpret interferometric radar/SAR data for topographic mapping and surface displacement applications.

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Based on that, the 2-D imaging concept used in synthetic aperture radar imaging is treated.

Then, we expand further on radar and SAR interferometric (InSAR) concepts and processing steps for single interferograms and stacks of interferograms also using persistent scatterer interferometry (PSI) to measure deformation based on time series of interferometric SAR data.

Finally, the 3-D radar imaging case (SAR tomography) is put into context with PSI/InSAR time series as an extension of the more classical interferometric approaches thereby closing the circle around the strongly related concepts of SAR imaging and interferometry.
It is highly recommended that the student has previously taken the following courses:
102-0617-00L: Basics and Principles of Radar Remote Sensing
and
102-0617-01L: Methodologies for Image Processing of Remote Sensing Data

103-0687-00L Cadastral Systems W 2 credits 2G J. Lüthy

Abstract
Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society.

Objective
Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre and spatial data infrastructures. The link between cadastral systems, gender equality, economic prosperity and the contribution to the achievement of the United Nation Sustainable Development Goals (UN SDG) is discussed. The Swiss cadastral system ("Amtliche Vermessung") as well as a number of international systems in developed as well as in developing countries are discussed. The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.

Content
Origin and purpose of cadastral systems
Importance of documentation of property information
Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)
Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment
Swiss cadastral system
- legal basis
- organisation
- Technical implementation
- Quality and integrity assurance
- profession
- Embedding cadastral data in the national spatial data infrastructure

Digital revolution and access to data
Benchmarking and evaluations
International trends, developments and initiatives to strengthen property rights

Literature
Adlington, G. (2021): Real Estate Registration and Cadastre - Practical Lessons and Experiences

851-0724-01L Real Estate Property Law W 3 credits 3V S. Stucki, R. Müller-Wyss

Particularly suitable for students of D-ARCH, D-BAUG, D-USYS

Abstract
Fundamental concepts of Land Register Law and Land Surveying Law (substantive and procedural rules of Land Register Law, the parts and the relevance of the Land Register, process of registration with the Land Register, legal problems of land surveying, reform of the official land surveying).

Objective
Overview of the legal norms of land registry and surveying law.

Content
Basic principles of material and formal land registry law, components of the land register, consequences of the land registry, the registration process, legal problems of surveying, the reform of official surveying, liability of the geometer.

Lecture notes
Abgegebene Unterlagen: Skript in digitaler Form

Literature
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
Taught competencies

<table>
<thead>
<tr>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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</table>

Social Competencies

| Communication | not assessed |
| Cooperation and Teamwork | assessed |
| Customer Orientation | assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity | assessed |
| Negotiation | assessed |

Personal Competencies

| Adaptability and Flexibility | not assessed |
| Creative Thinking | assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | assessed |
| Self-awareness and Self-reflection | assessed |
| Self-direction and Self-management | not assessed |

103-0187-01L Space Geodesy

Abstract

Objective
Overview of GNSS, Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments and observation equations. Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the atmosphere. Signal propagation in the ionosphere and troposphere for the different observation techniques and the determination of atmospheric parameters. Equation of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation theory and the determination of satellite orbits.

Lecture notes
Script M. Rothacher "Space Geodesy"

Complementary Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>103-0258-00L</td>
<td>Interoperability of GIS</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Schito</td>
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<tr>
<td>103-0780-80L</td>
<td>GIS and Geoinformatics Lab</td>
<td>W</td>
<td>4 credits</td>
<td>4P</td>
<td>P. Kiefer</td>
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<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>W</td>
<td>5 credits</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
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</table>

Autumn Semester 2022
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Objective
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Content
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
25': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

Cartography Lab

Independent practical work in cartography

Objective
Independent practical work in cartography

Content
Choice of theme upon individual agreement

Lecture notes
The task assignments and selected documentation will be provided as PDF.

Prerequisites / notice
Prerequisite: Statistics and Probability Theory, Geoprocessing and Parameter estimation, Geodetic Reference Systems and Networks

Introduction to Scientific Computation

Introduction to tools, techniques, and methods for data processing and analysis.

Objective
Get ready to work with data of different origin. Learn Python and tools to the level which allows attacking data related problems. Basic introduction to numerical algorithms for efficient problem solving

Content
Python for scientific programming, fast numerical computations and data visualisation.

Lecture notes
Further information at http://www.karto.ethz.ch/studium/lehangebot.html

Prerequisites / notice
Basic probability theory and statistics, linear algebra, basic programming skills

Project Works

Master's Thesis

Only for Geomatics MSc. Programme Regulations 2022.

Before starting the Master's thesis, students must have
a. obtained the Bachelor's degree;
b. fulfilled all specified admission conditions, if any;
c. acquired at least 90 credits in the Master's programme, including 12 credits in the area of the interdisciplinary project.

Abstract
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective
To work independently and to produce a scientifically structured work.

Content
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.
### Major in Engineering Geodesy and Photogrammetry

<table>
<thead>
<tr>
<th>Number</th>
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<td>103-0287-00L</td>
<td>Image-based Mapping</td>
<td>O</td>
<td>6</td>
<td>2G</td>
<td>K. Schindler</td>
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<td></td>
<td>Application of photogrammetry and remote sensing methods for mapping and Earth observation.</td>
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<td></td>
<td>Learn how to apply photogrammetry, image analysis and machine learning to mapping tasks; hands-on experience in implementing automatic image analysis methods, and in judging their results.</td>
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<td></td>
<td>Basics of knowledge of photogrammetry, image processing and machine learning.</td>
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<td>103-0787-00L</td>
<td>Project Parameter Estimation</td>
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<td>3</td>
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<td>J. A. Butt, T. Medic</td>
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<td>Solving engineering problems with modern methods of parameter estimation for network adjustment in a real-world scenario; choosing adequate mathematical models, implementation and assessment of the solutions.</td>
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<td>Learn to solve engineering problems with modern methods of parameter estimation in a real-world scenario.</td>
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<td>Analysis of given problems, selection of appropriate mathematical models, implementation and testing using Matlab: Kriging; system calibration of a terrestrial laser scanner.</td>
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<tr>
<td>102-0617-00L</td>
<td>Basics and Principles of Radar Remote Sensing for Environmental Applications</td>
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<td>I. Hajnsek</td>
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<td>The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.</td>
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<td>5. Introduction into polarimetric SAR interferometry</td>
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<td>103-0687-00L</td>
<td>Cadastral Systems</td>
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<td>2G</td>
<td>J. Lüthy</td>
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<td>Origin and purpose of cadastral systems</td>
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<td>Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)</td>
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<td>Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment.</td>
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<td>Swiss cadastral system - legal basis - organisation - Technical implementation - Quality and integrity assurance - profession - Embedding cadastral data in the national spatial data infrastructure</td>
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<td>Digital revolution and access to data</td>
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<td>International trends, developments and initiatives to strengthen property rights</td>
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Computer Vision

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

Real Estate Property Law

Fundamental concepts of Land Register Law and Land Surveying Law (substantive and procedural rules of Land Register Law, the parts and the relevance of the Land Register, process of registration with the Land Register, legal problems of land surveying, reform of the official land surveying).

Objective
Overview of the legal norms of land registry and surveying law.

Content
Basic principles of material and formal land registry law, components of the land register, consequences of the land register, the registration process, legal problems of surveying, the reform of official surveying, liability of the geom-eter.

Literature
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

Applied Radar Remote Sensing

This course provides an introduction to processing and interpreting radar and synthetic aperture radar (SAR) remote sensing data. The primary topics of the course are interferometric techniques and related applications such as topography mapping and mapping of surface displacements, with a strong emphasis on solving practical problems using MATLAB.

Objective
Understand the concepts and techniques required to process and to adequately interpret interferometric radar/SAR data for topographic mapping and surface displacement applications.

At the end of the course the student is able to read, display, process, and interpret interferometric radar/SAR data using MATLAB.
Lecture notes/handouts for each topic will be provided online.

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by business skills. In this course, students will acquire the necessary knowledge and tools to start their own technology venture. They will be guided after the conceptual and preparatory phase to the launch of the venture, including the following phases: founding, financing, and growing a venture. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases. The rationale behind the structure of the course follows the idea that technology and business knowledge are closely related and that a basic understanding of both is necessary to complement technical skills.

The course starts with the real-aperture radar case and a first introduction to the concept of radar interferometry with applications to topographic mapping and mapping of surface displacements.

363-0790-00L Technology Entrepreneurship

**Objective**
- After this course the students should be able to:
  - describe the most important established national and international spatial and temporal reference systems;
  - describe the techniques, processes, and institutions needed to establish and maintain reference frames;
  - select appropriate reference systems and frames for specific geospatial modeling/analysis tasks;
  - carry out coordinate transformations, conversions, and time operations on geospatial data, taking into account and quantifying the uncertainties;
  - combine geospatial data originally referring to different reference frames into a single reference frame.

**Prerequisites / notice**
- It is highly recommended that the student has previously taken the following courses:
  - 102-0617-00L: Basics and Principles of Radar Remote Sensing
  - 102-0617-01L: Methodologies for Image Processing of Remote Sensing Data
- It is also recommended that students have basic Python programming skills.

**Literature**
- Additional reading material:
  - ISBN: 978-0-306-47633-4
  - https://doi.org/10.1007/10.0070-306-47633-9

**Prerequisites**
- Basic probability theory and statistics, linear algebra, basic programming skills
- Libraries for data processing.
- Python for scientific programming, fast numerical computations and data visualisation.

**Content**
- This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.
- This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are:
  - entrepreneurship as a process of taking action to create value;
  - an introduction to entrepreneurial processes;
  - entrepreneurial decision making and problem solving.

**Objective**
- This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.

**Abstract**
- Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding. This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

**Objective**
- After this course the students should be able to:
  - describe the most important established national and international spatial and temporal reference systems;
  - describe the techniques, processes, and institutions needed to establish and maintain reference frames;
  - select appropriate reference systems and frames for specific geospatial modeling/analysis tasks;
  - carry out coordinate transformations, conversions, and time operations on geospatial data, taking into account and quantifying the uncertainties;
  - combine geospatial data originally referring to different reference frames into a single reference frame.

**Prerequisites**
- Basic probability theory and statistics, linear algebra, basic programming skills
- Libraries for data processing.

**Abstract**
- Introduction to tools, techniques, and methods for data processing and analysis.

**Abstract**
- Get ready to work with data of different origin. Learn Python and tools to the level which allows attacking data related problems. Basic introduction to numerical algorithms for efficient problem solving

**Abstract**
- Understanding the major observation techniques in space geodesy as modern methods applied in Earth system monitoring (geometry, rotation and gravity field of the Earth and the atmosphere), in national surveying and navigation.

**Abstract**

**Abstract**
- Understanding the major observation techniques in space geodesy as modern methods applied in Earth system monitoring (geometry, rotation and gravity field of the Earth and the atmosphere), in national surveying and navigation.

**Abstract**
- Understanding the major observation techniques in space geodesy as modern methods applied in Earth system monitoring (geometry, rotation and gravity field of the Earth and the atmosphere), in national surveying and navigation.
Overview of GNSS, Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments and observation equations. Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the atmosphere. Signal propagation in the ionosphere and troposphere for the different observation techniques and the determination of atmospheric parameters.

Equation of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation theory and the determination of satellite orbits.

Project Parameter Estimation

Solving engineering problems with modern methods of parameter estimation for network adjustment in a real-world scenario; choosing adequate mathematical models, implementation and assessment of the solutions.

Analysis of given problems, selection of appropriate mathematical models, implementation and testing using Matlab: Kriging; system calibration of a terrestrial laser scanner.

The task assignments and selected documentation will be provided as PDF.

Prerequisite: Statistics and Probability Theory, Geoprocessing and Parameterestimation, Geodetic Reference Systems and Networks

102-0617-00L
Basics and Principles of Radar Remote Sensing for Environmental Applications

The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. At the end of the course the student has the understanding of SAR basics and principles, SAR polarimetry, environmental parameter estimation from multi-parametric SAR data.

The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:

1. Introduction into SAR basics and principles
2. Introduction into electromagnetic wave theory
3. Introduction into scattering theory and decomposition techniques
4. Introduction into SAR interferometry
5. Introduction into polarimetric SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

Handouts for each topic will be provided.

First readings for the course:


Complete literature listing will be provided during the course.

103-0687-00L
Cadastral Systems

Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society.

Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre and spatial data infrastructures. The link between cadastral systems, gender equality, economic prosperity and the contribution to the achievement of the United Nation Sustainable Development Goals (UN SDG) is discussed.

importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.

Origin and purpose of cadastral systems
- Importance of documentation of property information
- Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)
- Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment
- Swiss cadastral system
  - legal basis
  - organisation
  - Technical implementation
  - Quality and integrity assurance
  - profession
  - Embedding cadastral data in the national spatial data infrastructure

Digital revolution and access to data
Benchmarking and evaluations
International trends, developments and initiatives to strengthen property rights


Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Social Competencies
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Critical Thinking

851-0724-01L
Real Estate Property Law
Particularly suitable for students of D-ARCH, D-BAUG, D-USYS
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. Basic principles of material and formal land registry law, components of the land register, consequences of the land register, the register process, legal problems of surveying, the reform of official surveying, and the geom-ether.

After this course the students should be able to describe the most important established national and international spatial and temporal reference systems; describe the techniques, processes, and institutions needed to establish and maintain reference frames; select appropriate reference systems and frames for specific geospatial modeling/analysis tasks; carry out coordinate transformations, conversions, and time operations on geospatial data, taking into account and quantifying the uncertainties; combine geospatial data originally referring to different reference frames into a single reference frame.

The course covers definitions, conventions and comprehensive real world examples of coordinate reference systems, time reference systems, their respective practical realization, and operations for changing data between them.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are entrepreneurial understanding.

Geospatial Reference Systems

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Geospatial Reference Systems

- A. Wieser
- Meineck, Geoinformationsrecht, Zürich 2015
- Meineck, Grundbuchrecht für die Praxis, Zürich 2016

Technology Entrepreneurship

- F. Hacklin
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
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- Self-awareness and Self-reflection
- Self-direction and Self-management

Technology Entrepreneurship

- Lecture slides and case material
- Not assessed
- Assessed
- Not assessed
- Assessed
- Assessed
- Assessed
- Assessed
- Assessed
- Not assessed

Major in GIS and Cartography

- Application Development in Cartography
- 6 credits
- 4 credits
- 4G
- L. Humi
- Assessed
- Not assessed
- 20 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, (E)MBA professors, company builders, patent experts, scale-up executives, …)
- 2h lecture - schedule (±):
  - 15': Introduction
  - 60': (Guest) lecture
  - 15': Discussion related to topic (in groups)
  - 10': Plenary discussion
  - 20': Q&A with (guest) lecturer
- 13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.
- See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html
Abstract
This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Objective
Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.

Content
- 3D cartography
- Web mapping
- Data processing
- Animations and interactions
- Map and UI design
- Web application development
- Programming (JavaScript).

Lecture notes
Handouts of the lectures and exercise documents are available on Moodle.

Prerequisites / notice
Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

103-0747-00L Cartography Lab W 6 credits 13A L. Hurni
Abstract
Independent practical work in cartography
Objective
Independent practical work in cartography
Prerequisites / notice
Cartography III

103-0687-00L Cadastral Systems W 2 credits 2G J. Lüthy
Abstract
Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society.
Objective
Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre and spatial data infrastructures. The link between cadastral systems, gender equality, economic prosperity and the contribution to the achievement of the United Nation Sustainable Development Goals (UN SDG) is discussed. The Swiss cadastral system ("Amtliche Vermessung") as well as a number of international systems in developed as well as in developing countries are discussed. The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.

Content
- Origin and purpose of cadastral systems
- Importance of documentation of property information
- Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)
- Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment
- Swiss cadastral system
  - legal basis
  - organisation
  - Technical implementation
  - Quality and integrity assurance
  - profession
  - Embedding cadastral data in the national spatial data infrastructure

Literature
Adlington, G. (2021): Real Estate Registration and Cadastre - Principles, Lessons and Experiences

103-0258-00L Interoperability of GIS W 3 credits 2G J. Schito
Abstract
Content: Transform geodata with the same content between files with a different structure.
Topics: System-neutral and model-driven approach with reality selection, conceptual modeling, flexible standard formats, one-to-one processors, semantic transformation.
Methods: Conceptual schema languages (UML and INTERLIS), data formats (ITF, XML), tools (ILI-Checker, Python, UMLT, FME, ModelBaker).

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1058 of 2345
Objective
- Explain and apply the model-driven approach based on standards
- Describe and use interoperability types
- Describe transfer formats and reformat them by one-to-one processors
- Explain object-oriented modelling (based on graphical and textual representation)
- Describe and use communication technologies and OGC Web services
  UML, EBNF, INTERLIS, ITF, XML, Python, FME, ModelBaker (QGIS), and PostgreSQL
- Apply appropriate software tools

Content
This lecture mainly treats the semantic interoperability of GIS, which describes a system-independent and model-driven approach for transforming geodata with the same content but different structure from one format into another (and vice versa). The list of topics entails the reality selection, conceptual modeling, flexible standard formats, one-to-one processors, and semantic transformation. In addition to introducing important concepts for semantic interoperability in theory, two popular workflows are presented and trained over several weeks, which include the conceptual schema languages UML and INTERLIS, the flexible transfer formats ITF and XML, the IILI-Checker, Python as parser, and UMLT with FME vs. ModelBaker (QGIS) with PostgreSQL for the semantic transformation.

Prerequisites / notice
Condition for participation: Successful bachelor course GIS II (old) or Geoinformationstechnologien und –analysen, GTA (new)

103-0778-00L
GIS and Geoinformatics Lab
W 4 credits 4P P. Kiefer

Abstract
Independent study project with novel geoinformation technologies. Information on past projects: http://gis-lab.ethz.ch/

Objective
This lab focuses on presenting spatial, temporal, and open data in tangible ways. Students will learn how to work with novel geoinformation technologies such as virtual/mixed reality or mobile applications. They will engage in teamwork, application design, programming and presenting their results.

851-0724-01L
Real Estate Property Law
W 3 credits 3V S. Stucki, R. Müller-Wyss

Abstract
Particularly suitable for students of D-ARCH, D-BAUG, D-USYS

Objective
Overview of the legal norms of land registry and surveying law.

Content
Basic principles of material and formal land registry law, components of the land register, consequences of the land register, the registration process, legal problems of surveying, the reform of official surveying, liability of the geom-eter.

Lecture notes
Abgegebene Unterlagen: Skript in digitaler Form

Literature
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hüttmann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Major in Planning

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<tr>
<td>103-0347-00L</td>
<td>Landscape Planning and Environmental Systems</td>
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<td>3 credits</td>
<td>2V</td>
<td>A. Grét-Regamey</td>
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Objective
The aims of this course are:
1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice
The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

103-0337-00L Site and Project Development

Abstract
The focus of the lecture Site & Project Development is on larger contiguous areas or sites and their urban, open space and infrastructural development. In this course, students work on a semester exercise in which they "develop" a specific large-scale project from practice and evaluate it economically, strategically and in terms of feasibility.

Objective
Students in this course will pursue the following learning objectives:
- Investigate and understand a given concrete project area and identify, evaluate and articulate the current problems and relevant issues within this area.
- Consolidate their knowledge in the essential topics of site & project development and apply this in a well-founded, argued and creative manner to address the task at hand.
- Organize and structure themselves while acquiring responsibilities in their interdisciplinary project teams. The teams consist of three to five fellow students that must develop innovative, viable and resilient concepts for a real project development in a given area. Their considerations should be presented in written form (project report) and in linguistic-visual form (final presentation). At the end of the course, the students critically reflect on their experiences with the group work process together with the course instructors.
- Acquire methodological knowledge in location & market analysis, 3D visualization of a project as well as in the financial assessment of a large-scale real estate project and use this knowledge to justify their considerations and evaluate their proposal.
- Development and strengthening of their individual position as planners (spatial, urban, transport planners, etc.) in relation to the questions formulated in the proposed project within the field of Site & Development as well as within their own discipline.
The lecture is divided into several thematic sections analogous to the essential topics of Site & Project Development. The students are accompanied both in the semester exercise and in the individual lectures by a large number of external guest speakers from the praxis-field, which means that the lecture will not only thematically examine the relevant areas of Site & Project Development, but also will offer the students exclusive, practice-oriented insights. The relevant methodological knowledge for the semester exercise is imparted and, due to the proximity to practice, the students gain exclusive insights into possible professional fields of activity. In this lecture, students apply their already acquired and newly learned skills, especially in interdisciplinary teams, and work on an exciting, motivating and relevant question from the practice.

Major topics covered in the lecture include:
- Urban planning
- Location and market analysis
- Real estate development, financing and valuation
- Project development and decision-making from the perspective of investors
- Open space design and landscape architecture
- Sustainable building and sustainability certification
- Mobility, parking issues, travel models
- Cooperative planning and participation processes, mediation
- Gendered planning in project development
- Inner development & urban quality

Parallel to the lecture series, students work in interdisciplinary teams on a real-life task. In the course of the semester exercise, the lecture material is deepened and what has been learned is applied. The students visit the project area at the beginning of the semester as part of an excursion. Specific large-scale projects such as the Gaswerkareal Bern, the Sihl-Manegg Areal Zurich (Greenocity) or the Areal Alter Platusmarkt (Nidfeld) Lucerne will be dealt with. For the possible development of the given site, visions are developed by the students on the basis of a comprehensive location and market analysis and a utilization concept is developed. In the process, the students are accompanied by experts and regularly discuss their ideas and proposed solutions with their supervisors.

Lecture notes
- Handouts of the lectures
- Extracts from relevant scientific articles and theory literature

Exercise material
Download: https://irl.ethz.ch/de/education/vorlesungen/msc/project_development.html

Literature
References in the lecture notes

Prerequisites / notice
none

Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Self-direction and Self-management</td>
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103-0317-00L Spatial Planning and Development

Only for master students, otherwise a special permission by the lecturer is required.

Abstract
The course deals with important theoretical, material and methodical foundations for action and decision-making of spatial relevance. This course discusses central tasks and possible solutions for current and future challenges of spatial development in Switzerland and Europe.

Objective
Spatial development deals with the development, formation and arrangement of our environment. In order to be able to mediate between the different demands, interests and projects of multiple actors, a forward-looking, action-oriented and robust planning is necessary. It is committed - in the sense of a sustainable spatial development - to the economical handling of resources, in particular of the non-replicable resource soil.

The lecture introduces necessary basic knowledge and is based on the following main topics:
- Inward development and challenges of spatial transformation
- Planning approaches and The (political) steering of spatial development
- Interplay of formal and informal processes and processes across different scales of spatial development
- Methods of action-oriented planning in situations of insecurity
- Integrated space and infrastructure development
- Different types of participation in spatial development

By taking up the lecture, the students are able to recognize cross-scale, complex tasks of spatial development and transformation and to use their theoretical, methodical and professional knowledge to clarify them.
Content
- Planning approaches and political organization in Switzerland
- Tasks of spatial relevance
- Key figures and ratios
- Drivers of spatial development
- Steering spatial development I: Policy
- Steering spatial development II: Formal and informal instruments
- Organizing spatial development I: Governance
- Organizing spatial development II: Processes and organization
- Methods in spatial planning I
- Methods in spatial planning II
- Planning in complex situations
- Participation in spatial development
- Present and future core tasks of spatial development

Lecture notes
Further information and the documents for the lecture can be found on the homepage of IRL/STL

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Cooperation and Teamwork</td>
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<td>Critical Thinking</td>
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</table>

103-0417-02L Methodology of Planning Research and Practice

W 3 credits 2G
A. Peric Momcilovic, T. Hug, R. Streit

Does not take place this semester. Only for master students, otherwise a special permission by the lecturer is required.

Abstract
This course deals with scientific and applied methods and the ways of thinking that are useful in planning practice as well as in scientific research. Students are offered interdisciplinary knowledge from planning practice and research, behavioural economics and social sciences. New perspectives on planning are opened up, which can lead to better results in future projects and research.

Objective
Keeping the general aim of exploring the basic methodologies in spatial planning research and practice, the specific course learning objectives are as follows:
- to address complex real-world spatial problems in adequate ways
- to know relevant theories and maxims that are subject to specific methods of problem solving
- to identify key questions and key concepts in contemporary planning research
- to select appropriate research methods to properly address the research questions

In practical terms, students:
- learn to deal with uncertainties and estimate quantities
- improve their ability to take decisions based on incomplete data and information
- are informed about different (qualitative and quantitative) methods and techniques for spatial research
- are skilled for writing simple research essays
- are urged to question their own knowledge and challenge the course of action taken in planning processes

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Autumn Semester 2022
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The course is based on the following questions:

How do we deal with complex issues in planning?
- Forms of knowledge, half-knowledge and not knowing
- Occurrence and explanation patterns for irrational behaviour
- Spatial research and planning practice
- Planning maxims
- Mapping complex topics in research questions

How do we generate knowledge about complex issues?
- Methods for scientific data generation
- Applied handling of quantities and probabilities
- Estimating despite uncertainties
- Opportunities of digitisation in planning (Participation, BigData)

How do we react to complex questions in planning?
- Methods of scientific data analysis
- Making decisions despite incomplete information
- Dealing with robustness and fragility

More specifically, the lectures focus on the following topics (NB: Some content units will be presented in English, they are marked with *asterisk below)
- (Half-) knowledge/behaviour/irrationals
- Initial situation: Solving complex problems
- Behavioural patterns, occurrence and explanation patterns for irrational behaviour
- Methods for solving complex tasks in planning practice
- Spatial research and planning practice - connections, differences, overlaps
- Challenges in the solution of complex tasks: System delimitation, interdisciplinarity, retrospective vs. prospective approach (descriptive vs. action-oriented, "reflected scenario building")
- Planning maxims
- *Methodology in spatial research
- *Research design
- *Research questions (types of research questions; research questions, hypotheses and theories); justification of research question
- Data generation methods (interviews and questionnaires, ethnography and observation, documents, official statistics)
- Dealing with quantities, estimations, anchor effect
- Importance of scales and key figures in planning
- Estimation methods
- Danger of the anchor effect
- Digitization in planning
- New data sources and sizes
- Opportunities and challenges through digitisation in planning
- Data analysis methods (quantitative and qualitative data; quantitative analysis of survey data; qualitative analysis - content analysis, discourse analysis, case study, comparative research)
- *Research ethics
- Decisions based on incomplete information
- Dealing with complex systems/roughness
- *Role of science in planning - the perspective of both research and practice

Learning materials: available online (Moodle) before corresponding lecture.


Taught competencies

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<tr>
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<td>Self-direction and Self-management</td>
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101-0427-01L Public Transport Design and Operations W 6 credits 4G F. Corman, T.-H. Yan

Abstract
This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.
Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view. At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning, timetabling and tactical planning, and related mathematical approaches, operations, and quantitative support to operational problems, evaluation of public transport systems.

Content

Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes

Lecture slides are provided.

Literature

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Transport Planning Methods

101-0417-00L
W 6 credits
4G K. W. Axhausen

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Lecture notes
Moodle platform (enrollment needed)

Literature

103-0347-00 V Landscape Planning and Environmental Systems (GIS Exercises) 3 credits 2U A. Grêt-Regamey, C. Brouillet, M. Galleguillos Torres, N. Klein

Abstract
The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective
- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies

Content
- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes
A script and presentation slides for each exercise will be provided on Moodle.

Literature
Will be named in the lecture.

Prerequisites / notice
Basic GIS skills are strongly recommended.

Taught competencies

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Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

103-0569-00 L European Aspects of Spatial Development W 3 credits 2G A. Peric Momcilovic

Abstract
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective
Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making
The documents for the lecture will be provided at the moodle.

Recommended literature:

- Governance models:

- Planning models:

EU as a political context:

Territorial cooperation in Europe:

Planning systems in Europe:

Prerequisites / notice

Only for master students, otherwise a special permission by the lecturer is required.

Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed

Social Competencies

- Decision-making: assessed
- Communication: assessed
- Cooperation and Teamwork: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed

Personal Competencies

- Adaptable and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Seminar Work

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<th>Number</th>
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<td>103-0817-00L</td>
<td>Geomatics Seminar</td>
<td>O</td>
<td>4</td>
<td>2S</td>
<td>K. Schindler, K. W. Axhausen, A. Grét-Regamey, L. Hurni, M. Raubal, B. Soja, A. Wieser</td>
</tr>
</tbody>
</table>

Abstract

Introduction to general scientific working methods and skills in the core fields of geomatics. It includes a literature study, a review of one of the articles, a presentation and a report about the literature study.

Objective

Learn how to search for literature, how to write a scientific report, how to present scientific results, and how to critically read and review a scientific article.

Content

A list of topics for the literature study are made available at the beginning of the semester. A topic can be selected based on a moodle.
Prerequisites / notice

Agreement with one of the responsible Professors is necessary.

#### Interdisciplinary Project Work

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<tr>
<th>Number</th>
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<td>Interdisciplinary Project</td>
<td>O</td>
<td>12</td>
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</table>

Abstract
Working on a concrete interdisciplinary task in Geomatics

Objective
Promote independent, structured and scientific work in an interdisciplinary context; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

Content
The project work is supervised by a professor. Students can choose from different subjects and tasks.

Prerequisites / notice
The project can be carried out in German upon mutual agreement between supervisor and student.

#### Master’s Thesis

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<th>Number</th>
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</table>

Abstract
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective
To work independently and to produce a scientifically structured work.

Content
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

#### Electives

The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

#### Recommended Electives of Master Degree Programme

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<tr>
<th>Number</th>
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<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>W</td>
<td>5</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
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</table>

Abstract
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Objective
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

Content
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice
Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

#### Electives ETH Zurich

Course Catalogue of ETH Zurich

#### Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

see Science in Perspective: Language Courses ETH/UZH

#### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
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<td>103-0132-AAL</td>
<td>Geodetic Metrology Fundamentals</td>
<td>E-</td>
<td>6</td>
<td>13R</td>
<td>A. Wieser</td>
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Abstract
Introduction to the most important sensors, operation and calculation methods of Geodetic Metrology
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Prerequisites / notice</th>
<th>Taught competencies</th>
<th>Literature</th>
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<tr>
<td>103-0214-AAL</td>
<td>Cartography Fundamentals</td>
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<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td></td>
<td>Objective</td>
<td>Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.</td>
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<td>Content</td>
<td>Definitions &quot;map&quot; and &quot;cartography&quot;, map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, press technology, printing technology, topographic maps, map critics.</td>
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<td>Abstract</td>
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<td>Lecture notes</td>
<td>Will be distributed module by module.</td>
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<td>Further information at <a href="http://www.karto.ethz.ch/studium/lehrangebot.html">http://www.karto.ethz.ch/studium/lehrangebot.html</a></td>
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<td>103-0253-AAL</td>
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<tr>
<td></td>
<td>Objective</td>
<td>The students are capable of analysing measurements with with appropriate methods. They can optimally extract model parameters from real measurements and are able to analyse and to retrieve additional information from time series. They understand the underlying algorithms of different geodetic analysis tools and processing methods.</td>
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<td>Content</td>
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<td></td>
<td>Abstract</td>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Prerequisites / notice</th>
<th>Taught competencies</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0846-AAL</td>
<td>Computer Science II</td>
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<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td></td>
<td>Objective</td>
<td>Working with a professional programming environment (Eclipse).</td>
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<td>Content</td>
<td>In the course &quot;Computer Science II&quot;, the competencies of programming, modeling and data analysis &amp; interpretation are taught, applied and examined. The students will be able to write simple programs and to modify existing programs.</td>
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<td>Abstract</td>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Prerequisites / notice</th>
<th>Taught competencies</th>
<th>Literature</th>
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<tbody>
<tr>
<td>406-0141-AAL</td>
<td>Linear Algebra</td>
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<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<td>Any other students (e.g. incoming exchange students,</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1068 of 2345
Abstract
Introduction to Linear Algebra and Numerical Analysis for Engineers. This reading course is based on chapters from the book "Introduction to Linear Algebra" by Gilbert Strang (SIAM 2009), and "A first Course in Numerical Methods" by U. Ascher and C. Greif (SIAM, 2011).

Objective
To acquire basic knowledge of Linear Algebra and some aspects of related numerical methods and the ability to apply basic algorithms to simple problems.

Content
1 Introduction, calculations using MATLAB
2 Linear systems I
3 Linear systems II
4 Scalar- & vectorproduct
5 Basics of matrix algebra
6 Linear maps
7 Orthogonal maps
8 Trace & determinant
9 General vector spaces
10 Metric & scalar products
11 Basis, basistransform & similar matrices
12 Eigenvalues & eigenvectors
13 Spectral theorem & diagonalisation
14 Repetition

Literature

Prerequisites / notice
Knowledge of elementary calculus

406-0242-AAL
Analysis II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Mathematical tools of an engineer

Objective
Mathematics as a tool to solve engineering problems, mathematical formulation of problems in science and engineering. Basic mathematical knowledge of an engineer.

Content
Linear systems I
Linear systems II
Scalar- & vector product
Basics of matrix algebra
Linear maps
Orthogonal maps
Trace & determinant
General vector spaces
Metric & scalar products
Basis, basistransform & similar matrices
Eigenvalues & eigenvectors
Spectral theorem & diagonalisation
Repetition

Literature
Textbooks in English:
- J. Stewart: Multivariable Calculus, Thomson Brooks/Cole
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus
- M. Akveld, R. Sperb, Analysis II, vdf
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

406-0243-AAL
Analysis I and II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems. Basic mathematical knowledge for engineers.

Content
Complex numbers.
Calculus for functions of one variable with applications.
Simple Mathematical models in engineering.

Literature
Textbooks in English:
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus
Textbooks in German:
- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

406-0603-AAL
Stochastics (Probability and Statistics)
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".
Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435
  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m1757b/

406-0062-AAL Physics I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

Content
Book:

Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002, 544 S, ca.: Fr. 68.-

406-0063-AAL Physics II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content
Book:

Chapters:

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003, Fr. 77.-

252-0856-AAL Computer Science

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Objective
Primäres Lernziel der Vorlesung ist die Befähigung zum Programmieren mit C++. Studenten beherrschen nach erfolgreichem Abschluss der Vorlesung die Mechanismen zum Erstellen eines Programms, sie kennen die fundamentalen Kontrollstrukturen, Datenstrukturen und verstehen, wie man ein algorithmisches Problem in ein Programm abbildet. Sie haben eine Vorstellung davon, was "hinter den Kulissen" passiert, wenn ein Programm übersetzt und ausgeführt wird.

Sekundäre Lernziele der Vorlesung sind das Computer-basierte, algorithmische Denken, Verständnis der Möglichkeiten und der Grenzen der Programmierung und die Vermittlung der Denkart eines Computerwissenschaftlers.

Content

Die Konzepte der Vorlesung werden jeweils durch Algorithmen und Anwendungen motiviert und illustriert.

Lecture notes
Ein Skript in englischer Sprache wird semesterbegleitend herausgegeben. Das Skript und die Folien werden auf der Vorlesungshomepage zum Herunterladen bereitgestellt.

Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010

103-2233-AAL
GIS Basics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Fundamentals in geoinformation technologies: database principles, including modeling of spatial information, geometric and semantic models, topology and metrics; practical training with GIS software.

Objective
Know the fundamentals in geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects.

Content
Modelling of spatial information
Geometric and semantic models
Topology & metrics
Raster and vector models
Databases
Applications
Labs with GIS software

Literature

103-0187-AAL
Satellite Geodesy
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Objective
Understanding the major observation techniques in space geodesy as modern methods applied in Earth system monitoring (geometry, rotation and gravity field of the Earth and the atmosphere), in national surveying and navigation.

Content
Overview of GPS, VLBI, Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments and observation equations. Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the ionosphere and troposphere for the different observation techniques and the determination of atmospheric parameters. Equation of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation theory and the determination of satellite orbits.

Literature
Script M. Rothacher "Space Geodesy"

401-0363-AAL
Analysis III
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling; Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling; Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Literature
For reference/complement of the Analysis I/II courses:
Christian Blatter: Ingenieur-Analysis (Download PDF)

Prerequisites / notice
Up-to-date information about this course can be found at:
http://www.math.ethz.ch/education/bachelor/lectures/hs2013/other/analysis3_itet

Abstract
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

Objective
The goal is to familiarise students with the principles and tools of machine learning, and to enable them to apply them for practical data analysis.

Content
- multivariate probability distributions; comparison of distributions; regression; classification; model selection and cross-validation; clustering and density estimation; mixture models; neural networks

Literature
- Hastie, Tibshirani, Friedman: The Elements of Statistical Learning, Springer 2009
- Duda, Hart, Stork: Pattern Classification, Wiley 2012

Geomatics Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
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<tr>
<th>V</th>
<th>lecture</th>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>851-0050-00L</td>
<td>Theorie and Methodology MAGPW</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>F. Forster, L. Schurrer</td>
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<tr>
<td></td>
<td>Only for MA History and Philosophy of Knowledge.</td>
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<tr>
<td>Abstract</td>
<td>Introduction to methods, theories and work techniques of the disciplines represented in the study programme.</td>
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<tr>
<td>Objective</td>
<td>The interdisciplinary seminar is aimed exclusively at students of the master's program &quot;History and Philosophy of Knowledge&quot;. It is designed to give students an insight into the subjects represented in the degree program and their specific requirements, procedures, questions and working techniques.</td>
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<td>851-0197-00L</td>
<td>Medieval and Early Modern Science and Philosophy</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>to be announced</td>
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<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>The course analyses the evolution of the relation between science and philosophy during the Middle Age and the Early Modern Period.</td>
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<tr>
<td>Objective</td>
<td>The course aims are:</td>
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<td>- to introduce students to the philosophical dimension of science;</td>
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<td>- to develop a critical understanding of scientific notions;</td>
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<td>- to acquire skills in order to read and comment on scientific texts written in the past ages.</td>
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<tr>
<td>Content</td>
<td>The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.</td>
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<tr>
<td>853-0725-00L</td>
<td>History Part One: Europe (The Cradle of Modernity, Britain, 1789-1914)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>H. Fischer-Tiné</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series asks whether one single model of modernization prevailed on the &quot;Old Continent&quot; or whether we need to differentiate regionally. A special focus lies on the Swiss experience.</td>
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<tr>
<td>Objective</td>
<td>At the end of the lecture course, students can: (a) highlight the most important changes in the &quot;long nineteenth century&quot; in Europe (b) explain their long-term effects; and (c) relate these changes to global developments today.</td>
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<td>Content</td>
<td>The thematic foci include:</td>
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<td>- Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.</td>
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<tr>
<td>Lecture notes</td>
<td>Power Point Slides and references will be made available in digital form during the course of the semester.</td>
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<tr>
<td>Literature</td>
<td>Mandatory and further reading will be listed on the course plan that is made available as from the first session.</td>
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<tr>
<td>Prerequisites/notice</td>
<td>This lecture series does not build upon specific previous knowledge by the students.</td>
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<tr>
<td>851-0020-00L</td>
<td>Gender and Science</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>N. El Kassar, C. L. Blaser</td>
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<td>This lecture series offers an introduction to the relationship between gender and science, with a focus on the specific intersections with the sciences taught at ETH.</td>
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<tr>
<td>Abstract</td>
<td>This lecture series is designed to acquaint students from all levels and departments with the various ways in which gender perspectives matter for specific scientific disciplines, as well as for science in general. Students will learn to recognize and analyse the specific ways in which scientific theories and methods are gendered. They will be able to discuss and reflect how these topics are connected to their own scientific disciplines.</td>
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<tr>
<td>Objective</td>
<td>There is agreement across academic disciplines today that gender influences and structures the production of knowledge and that scientific knowledge production in turn shapes gender notions. Even within &quot;hard&quot; sciences such as mathematics, physics, engineering, etc., gender is a significant factor in determining what counts as &quot;objective&quot; knowledge, who can know it, what kind of knowledge is produced, or how this knowledge is acquired and justified. Feminist research aims to reveal how dominant conceptions of science and knowledge practices disadvantage women&quot;, and other subordinate groups, with the goal of reforming these practices. An important part of feminist critique is to show that such efforts substantially improve the overall quality of research. The semester will start with two introductory lectures acquainting students with research questions in the field of Gender and Science by summarizing its key concepts and methods. It will then continue as a series of weekly guest lectures by scholars from different scientific disciplines that provide accessible insights into the intersection between gender studies and the guest lecturer's research field. Students will thereby be encouraged to learn from concrete examples rather than abstract theory. The goal is for students to understand how to apply concepts and methods of gender studies to their particular disciplines. Intermediate discussions with the students will provide a forum for critically reflecting the content of the lectures and the connections to their own academic fields and practices.</td>
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<tr>
<td>Content</td>
<td>All lectures by the guest speakers will also be open to the broader ETH public, while the introductory and discussion sessions are only for registered course participants.</td>
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<tr>
<td>851-0084-00L</td>
<td>Sound Studies and Literature – A New Paradigm?</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Alon</td>
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<tr>
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<td>The lecture presents the methodological diversity of sound studies insofar as they are related to the study of literature and undertakes to critically assess exemplary works. It offers an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.</td>
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</table>
Is literature silent? The paper pages of the book or the screen of the tablet that we look at while reading might suggest so. Nevertheless, when reading, one cannot help but have the impression that literature contains sound. Doesn't it allow us to identify authors by their "voice," for example, or guide our reading through repetitions and assonances? Does it not seem to reproduce the sonic world?

In other words: How is the relationship between literature and sound to be thought of? In recent years a concept of "sound" has emerged in the realm of the so-called sound studies which thinks of acoustic phenomena in their connection with human perceptions and actions (Morat/Ziemer 2018). Research in the context of the 'sonic turn' assumes that literature both generates and stores sound and that our understanding of literature should be closely linked to the conceptualization and writing practice of sound as well as the conditions of its production and reception.

Strongly interdisciplinary, this research thus combines perspectives from the cognitive sciences, with approaches from the technical sciences and cultural studies. At times, it has argued to dispense with the traditional fixation on writing and instead to approach literature also through sound practices and listening techniques. These practices and techniques should not only be object of studies, but, employing "listening as a research method" (Holger Schulze), should be integrated into the research methodology.

The lecture will confront the methodological diversity of sound studies insofar as they are related to the study of literature and will undertake to critically assess them. It will offer an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.

Not only the specific genre of "Science Fiction", but fictitious (literary) texts in general are fundamentally about the forms and functions of schemes and simplifications. It means freeing oneself from the obligations that certain university systems impose on their students, with the risk of limiting one's view of the great authors Galileo, Italo Calvino and Primo Levi.

The course will explore, on the one hand, the central nodes of Galilean science and, on the other, its reception in two "hybrid" authors such as Calvino and Levi. Through the reading and commentary of texts and images, we will narrate the relationship between science and literature, starting from the contexts in which these three authors found themselves living and discussing the problems and issues that each of them had to deal with. This is the case with Galileo, Italo Calvino and Primo Levi. Each of them has been many things at once. The first was a scientist but also a philanthropist, a political activist; the second was a writer and a refined essayist and literary critic; the third was a chemist, writer and witness to an event that marked the history of the twentieth century.

The course will explore, on the one hand, the central nodes of Galilean science and, on the other, its reception in two "hybrid" authors such as Calvino and Levi. Through the reading and commentary of texts and images, we will narrate the relationship between science and literature, starting from the contexts in which these three authors found themselves living and discussing the problems and issues that each of them had to deal with.

No Borders: Galileo, Calvino, Primo Levi

W 3 credits
2V
M. Bucciantini

Pluralist Philosophy of Mathematics

W 3 credits
2V
R. Wagner

Literature and Knowledge / Science and Fiction

W 3 credits
2V
A. Kicher

Science and technology are projects that are usually described as "progressing". Earlier findings and inventions are used to create new ones. Later researchers stand on the "shoulders of giants" of those who worked before them. But is this a development toward truth and for the better?

Objective

Acquire knowledge of basic concepts of progress and their evaluation options.

Progress

W 3 credits
2V
M. Hampe
The U.S. philosopher Chauncey Wright wrote in 1865 in his critique of the famous 19th century popular philosopher Herbert Spencer: “Progress is a grand idea, – Universal Progress is a still grander idea. It strikes the key note of modern civilization. Moral idealism is the religion of our times. What the ideas of God, the One, and the All, the Infinite First cause, were to an earlier civilization, such are Progress and Universal Progress to the modern world, – a reflex of its moral ideas and feelings.” (Chauncey Wright, The Evolutionary Philosophy.... Vol. 1, 1901, S. 68). The lecture will give an introduction into the different concepts of progress and try to evaluate them against the background of the current epistemological situation.

851-0092-00L  Artificial vs Human?  W  3 credits  2G  L. Wingert

Abstract
KI-based machines and artificial agents are playing more and more a crucial role in our social and political life. Do they essentially differ from human intelligence and human actors or are they merely an (advanced) version of us? How should we judge on their role? For answering such questions one has to give an account of essential features of intelligence, reason, and agency.

Objective
Participants should learn to know some philosophical accounts of intelligence, reason, and agency. This knowledge should enable them to evaluate the pro and con of answers to questions of the following kind:

1. Is human deliberation and argumentation essentially algorithmic?
2. Is AI confined to smart solutions of given problems or is AI also able to revise the framing of problems?
3. Could artificial agents like robots be responsible for their behavior?
4. Do my smartphone and I constitute an extended, hybrid mind?
5. How should we deal with AI-based machines in our social and political life?

851-0093-00L  Ethical Issues in the Economy  W  3 credits  2G  L. Wingert

Abstract
Ecological crises and growing social inequalities rise the urgent question: Is the global way we are doing economics reasonable? – Which kind of wealth is illegitimate? Is a policy of de-growth needed for protecting our ecological niche? Will technological devices e.g. AI-driven market designs for public goods be the solution or is a change of attitudes necessary to cope with such problems?

Objective
Participants should learn to know and being enabled to evaluate answers to the following questions:

1. To which extent are economic success and wealth something deserved, and to which extent are they the outcome of lucky circumstances or favorable conditions? And what follows from the answer for the judgment on social inequalities?
2. How much consumption and growth are enough?
3. Which commons should not be privatized?
4. What should entrepreneurs and consumers be responsible for?
5. Does a sharing economy promote a responsible way of doing business?
6. Are technologies for regulating production and allocation of resources as well as regulating consumptions of goods apt to cope with problems of social inequality, of protecting our ecological niche, and do they empower producers, investors and consumers to act responsible?
7. What are the good things and what are the bad things about the global capitalist scheme doing business in the 21st century?
8. Do we need a de-globalization of doing economics?

851-0177-00L  Images of Computing  W  3 credits  2G  J. L. Gastaldi, O. Del Fabbro

Abstract
This seminar will explore different areas of our social and scientific life where computational practices have a critical impact. The goal is to provide a pluralistic conception of computing based on what computing looks like when dealing with topics as diverse as climate, law, art, or war. The lectures are delivered by researchers from ETH and abroad, with different disciplinary backgrounds.

Objective
By the end of the course, students will be able to describe and compare different conceptions and practices of computing from multiple disciplinary perspectives. They will be able to evaluate both the differences and the convergences between those conceptions, and critically assess their relation to current trends in science, technology, and society.

Content
Computing has become omnipresent in all dimensions of scientific and social life. Not only have cultural phenomena increasingly become the object of computational analysis, but computational practices have also proved inseparable from the cultural environment in which they evolve. Therefore, it is urgent to critically address the entanglement of computing practices with the main cultural challenges our epoch is facing. The global and collective nature of such problems requires a comprehensive perspective on computing, where social and cultural aspects occupy a central position. For these reasons, thinking about machines asks today for an interdisciplinary approach, where art is as necessary as engineering, anthropological insights as important as psychological models, and the critical perspectives of history and philosophy as decisive as theorems of theoretical computer science. In this new edition of the Turing Centre’s “Images…” lecture series, we will explore different areas of our current social and scientific life where computational practices have a critical impact in order to reflect on the multiple images of computing resulting from them. Instead of asking what computing is in general, the seminar intends to focus on what computing looks like when dealing, for instance, with a climate model, a text of law, a work of art, a mathematical proof, or a weapon of war. The goal of the course is to achieve a pluralistic conception of computing based on what computing looks like when dealing with topics as diverse as climate, law, art, or war. The lectures are delivered by researchers from ETH and abroad with different disciplinary backgrounds. As part of the Turing Centre, this seminar intends to sow the seed of a suitable and long-term environment for exchanging ideas between multiple fields in the natural sciences and the humanities.


Abstract
The lecture offers a survey of the historical trajectories taken by the countries of the Indian subcontinent from the 17th century to the turn of the 21st century. The thematic foci include, but are not limited, to an examination of the question whether or not there was a pre-European South Asian modernity.

Objective
Through this course students are acquainted with the history of one of the most important world regions. The objective is not only to introduce participants to a richly diverse civilization, they are also encouraged to look at interrelations and make comparisons with the West. Through this approach their knowledge of European history is contextualised in a global framework while simultaneously their intercultural sensitivity is being trained.

851-0157-28L  Life and Death  W  3 credits  2V  M. Hagner

Abstract
This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Objective
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0298-00L  The Modern Literary and Artistic Avantgarde in its European Dimension  W  3 credits  2V  S. S. Leuenberger

Abstract
The modernist Avant-Garde movements are characterized by a radical rhetoric of apocalypse and rebirth, the genesis of another world and a new mankind. The extension of the “intrinsic logic of the aesthetic form into the social fabric” (H. Ehrlicher), and likewise the intensive examination of the latest technical advancements, new forms of media and their combination, unites them.
Objective
Avant-garde movements are characterized by progressive notions on art, social and political issues as well as by radical criticism on the current circumstances. This is why the specific characteristics of the historic avant-garde of the early 20th century will be a central theme of this lecture; they cannot be separated from the experience of modernity, of the catastrophic course of the First World War, and of the concept of new models of society whose political implementation is a major goal after the end of the war.

The lecture is part of the ‘Science in Perspective’ course programme aimed at enabling the students to deal with avant-garde texts and artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter Bürger's assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-criticism".

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic perspective: literary texts and manifests by Heym, van Hoddela, Werfel, Lasker-Schüler, Toller, Marinetti, Ball, Tzara, Huesuntscheid, Breton, Goll, and others will be read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist Avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of technological innovations, second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and, following the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking resilience to totalitarian ideologies.

#### Seminars

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<tr>
<th>Number</th>
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<th>Hours</th>
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<td>701-0019-00L</td>
<td>Reading in Environmental Thinking</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>J. Ghazoul</td>
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**Abstract**
This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance, and shaped its relevance to society. Above all, the course seeks to give confidence and raise enthusiasm among students to read more widely around the broad subject of environmental sciences. Students will gain familiarity with the foundational texts, but also understand the historical context within which their academic and future professional work is based. More directly, the course will encourage debate and discussion of each text that is studied, from both the original context as well as the modern context. In so doing students will be forced to consider and justify the current societal relevance of their work.

**Content**
The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion.

Thereafter, in each week a text (typically a chapter from a book or a paper) considered to be seminal or foundational will be assigned by a course lecturer. The lecturer will introduce the selected text with a brief background of the historical and cultural context in which it was written, with some additional biographical information about the author. He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session. Presentation of the text requires the students to prepare by, for example: identifying the key points made within the text, identifying issues of particular personal interest and resonance, considering the impact of the text at the time of publication, and its importance now, evaluating the text from the perspective of our current societal and environmental position.

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

**Literature**
The specific texts selected for discussion will vary, but examples include: Leopold (1949) A Sand County Almanach
Carson (1962) Silent Spring
Jared Diamond (2005) Collapse

Discussions might also encompass films or other forms of media and communication about nature.

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<td>851-0426-00L</td>
<td>Paul Feyerabend's Anarchistic Theory of Knowledge</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>M. Hagner, M. Hampe</td>
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**Abstract**
Paul K. Feyerabend characterized his magnum opus “Against Method” as an ‘anarchistic theory of knowledge’. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

**Objective**
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

**Content**
We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

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<td>851-0011-00L</td>
<td>The Body in Global History</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>E. Valdameri</td>
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**Abstract**
While being the universal constant which is common to every human being in history, the body is also culturally and historically specific. In this seminar we will examine how ideas of the body have changed throughout history and how these ideas of the body can be useful to understand political, social, and cultural phenomena in particular historical settings.
Students learn the history of the body from mid-eighteenth century onwards through examples taken from the multidisciplinary scholarship on the body with a special, albeit not exclusive, focus on colonial and postcolonial contexts. More specifically, students are sensitized to the historical and cultural variabilities of the human body that challenge scientific understandings of it as an unchanging biological entity. Adopting a humanities perspective on topics like anatomy and surgery, the treatment of the insane, sexuality, physical culture, eugenics, and body productivity, the course looks at shifting attitudes to body health and fitness as well as by socioeconomic circumstances of modernity. It considers how bodies have historically concerned governments who have classified different (sections of) populations as ‘fit’ or ‘unfit’ to be members of a certain community.

The ‘long durée’ approach of the course allows to consider the continuities and changes in terms of scientific epistemologies and practices regarding the body. In doing so, debated contemporary issues such as assisted reproductive technologies and wearable systems of surveillance of the worker fatigue in the workplace are discussed.

The course is structured thematically, adopts a multidisciplinary approach, and uses academic texts as well as concrete examples. It intends to a) enable STEM students to develop new perspectives on their core subjects by bringing them in dialogue with the themes dealt with and by raising ethical questions; b) familiarise students in general with major topics in the field of the recent scholarship on the body and make them mindful of the multiple ways in which understanding the body and its relationship with culture and power can help think critically of the present we live in.

### Course Details

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<tr>
<th>Code</th>
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<td>851-0040-00L</td>
<td>Can It Be Permissible to Kill a Few in Order to Save Many?</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>N. Mazouz</td>
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<td>851-0042-00L</td>
<td>Democracy (Theory) and Challenges Posed by the Digital Transformation</td>
<td>W</td>
<td>3</td>
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<td>N. Mazouz</td>
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<td>851-0078-00L</td>
<td>Ignorance and Error in the Sciences</td>
<td>W</td>
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<td>851-0086-00L</td>
<td>War between Humans, or War against Nature?</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>O. Del Fabbro</td>
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<tr>
<td>851-0101-77L</td>
<td>Science and the State</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>R. Wagner</td>
</tr>
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</table>

**Objective**

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**Abstract**

- First, the relevant literature on moral justifications in trolley cases will be discussed (Foot, Thomson, Kamm, Otsuka, Kagan). Second, neuropsychological research on trolley cases (Greene, Haidt, Berk, Kamm) and third, applications of such moral reasoning in cases potentially arising in autonomous robots (Rahwan, Nyholm and Smids, Wolkenstein) will be considered.

**Content**

- First, an overview of different theories of democracy will be given in order to make explicit their normatively distinguished features. Second, using examples of the social application of digital technologies, controversies about their impact and normative evaluation are discussed. Third, these discourses are related to the models of democracy elaborated in the first part and analyzed.

**Objectives**

- Students will gain an overview of different theories of democracy and the associated different types of challenges to democracy posed by the digital transformation of society. They will be enabled to interpret complex texts, to identify the argumentation, to reflect critically and to put it up for discussion.

**Content**

- Researchers agree that the digital transformation of society is a challenge to democracy. What is disputed is how exactly it challenges or even endangers it. One reason for the disagreement is certainly due to different descriptions and assessments of the precise social effects and risks of various digital technologies. A second reason has to do with the diversity of theories of democracy. In democratic theory, a distinction is usually made between liberal, republican, pluralist-participatory, and deliberative models of democracy (and often many more). Depending on which model is used (and how exactly it is determined), political participation, elections, accountability of politicians, the role of central legal-political institutions (such as the constitution), political culture, and the quality of discourse in the political public sphere are conceived and evaluated differently.

**Abstract**

- In a first step, this seminar will provide an overview of different theories of democracy, with the aim of making explicit the normative features of important elements of democracy (such as political participation). In a second step, examples of the social application of digital technologies are used to discuss both divergent descriptions of their impact and controversies about normative evaluations in the research literature. In a third step, these discourses are related to the models of democracy elaborated in the first part and analyzed.

**Objective**

- Students learn about the different types of argumentative texts and their historical context. They learn to understand the descriptive and critical values of texts in regard to the topic of war.

**Taught competencies**

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The meaning of the "beautiful" seems hard to pin down. Yet intersubjective and objective criteria of the beautiful nevertheless exist. The foundation of aesthetics as a "science" of the beautiful based on sensuous experience temporarily suspended this tension. Since modernity, the question of the beautiful has been ever more open. We shall approach this question theoretically and historically.

The learning objective is twofold: the students should get to know the most important traditions of philosophical thinking about the morality of war; and they should learn to interpret philosophical texts, to think through the difficult problems that the texts raise, and to argue for and against the theses that are made explicit in the various approaches.

The seminar promotes an understanding of seminal texts in the early philosophy of science (M. Polanyi, J.D. Bernal, etc.) in the context of ideological struggles in the 1930s and 1940s and of the debates about knowledge, science, and society at that time. Moreover, it provides insights into the political and economic foundations of funding policies for education, science, and research that were developed since the 1970s.

Science needs to be popularized in order to have an impact on society. Conversely, what is thought, read, and communicated outside the universities has an effect on research. The seminar deals with the history of popular knowledge focusing on the non-fiction book.

The focus of the seminar is the controversial debate in contemporary philosophical thinking about the moral problem of war, humanitarian movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

Knowledge cannot be separated from the forms in which it is expressed. An important genre of (popular) knowledge representation is non-fiction.

Knowledge is an area extensively covered by violent political conflicts. The seminar will shed light on the changing relationship between knowledge, the market, and the book format. What topics/subjects are en vogue at particular times? How do non-fiction books produce and narrate knowledge? How do they establish authority, how do they create and disseminate knowledge, how do they shape or reflect the political and social status of the society of the time? What modes of production and distribution are used? How do they change over time?

The seminar will look at how non-fiction books are actually made and how they are published and read at different times. Using examples from the history of non-fiction (Yuval N. Harari to Rachel Carson, C.W. Ceram to Charles Darwin/Ernst Haeckel), the seminar will shed light on the changing relationship between knowledge, the market, and the book format. What topics/subjects are en vogue at particular times? How do non-fiction books produce and narrate knowledge? How do they establish authority, how do they shape or reflect the political and social status of the society of the time? What modes of production and distribution are used? How do they change over time?

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Abstract
It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is inherently narrative and therefore articulated best in the form of narrations. But is it even possible to narrate time? What kind of translation is that? And, above all, what are the costs of, and the resistances to, such a translation?

Objective
The overall aim of this class is to reflect, in theory and through literature, upon the fundamental category of time, the critical insight being that a discretely progressing and uniformly clocked time is only one way of looking at temporal processes. In fact, this standard clock, with which the mathematical sciences calculate and which is mainly used in the technical field, is only a special case, an abstraction for the purpose of more convenient division, measurement and precalculation of time processes. The world, however, also holds more complex experiences of time, which cannot be calculated mathematically or explained by the law of causation alone. Certain experiences of time simply necessitate narratives (which is why even in the philosophy of science scholars have come to regard narrative as a legitimate and indeed indispensable means of explanation). Literature makes all this tangible by bringing the uneven clockings, overlaps, and loops of experiential time to light, which still holds true when the literary representation of time fails, i.e., when it becomes clear that the transfer of experienced time into narrated time also entails certain deformations and even losses.

### 851-0527-00L

**Introduction to the History of Technology: Concepts, W and Current Debates**

**Abstract**
Technology and society cannot be separated. No society functions without technology. The seminar offers a problem-oriented introduction to basic questions of the history of technology, introduces approaches to the history of technology and discusses selected, ongoing debates.

**Objective**
The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.

**Content**
History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

**Prerequisites / notice**
Beginn 2. Semesterwoche (27.9.2022)

### 851-0360-00L

**The Noise of Culture: Literature, Babel, and the Meaning of Meaning**

**Abstract**
When noise—din in the pub, static on the line, attenuation of the signal—a problem for communication? When is noise art? We'll ask James Joyce.

**Objective**
To gain familiarity with noise as a technical, systems-theoretical, and philosophical concept.

**Content**
To draw connections between noise as a mythical problem (Babel) and noise as a telecommunications problem.

**Prerequisites / notice**
Beginn 2. Semesterwoche (27.9.2022)

### Semester Report

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### Semester Paper

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<tr>
<td>862-0011-26L</td>
<td>Term Paper in Practical Philosophy (HS 2022)</td>
<td>W</td>
<td>5</td>
<td>11A</td>
<td>Lecturers</td>
</tr>
<tr>
<td>862-0012-27L</td>
<td>Term Paper in Literature and Culture (HS 2022)</td>
<td>W</td>
<td>5</td>
<td>11A</td>
<td>Lecturers</td>
</tr>
<tr>
<td>862-0013-27L</td>
<td>Term Paper History of the Modern World (HS 2022)</td>
<td>W</td>
<td>5</td>
<td>11A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1079 of 2345
Objective: Developing a case-specific approach, coping with relevant literature and an enhancing one's competence in the critical evaluation of historic sources are the learning targets of this course.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>862-0015-08L</td>
<td>Term Paper in History and Philosophie of Mathematical Sciences (HS 2022)</td>
<td>W</td>
<td>5</td>
<td>11A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract: Term paper that allows students to explore a topic of their choice in greater depth, applying the fundamental knowledge they have acquired so far.

Objective: The development of a research question, the careful handling of the secondary literature and an increased source-critical competence form the learning objective.

Major Courses

**Essays**

In each subject of the master reading lists are handed out. The books on these lists are the subject of the tutorials one has to attend with the teachers that are named in the Leitfaden. In three subjects essays are to be written about works on these lists.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>862-0021-00L</td>
<td>Essay on Readings in History of Technology (HS)</td>
<td>W</td>
<td>10</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract: This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.

Objective: Writing this essays intents to become acquainted with methods, tools and concepts relevant for the students master thesis.

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</tr>
</thead>
<tbody>
<tr>
<td>862-0023-00L</td>
<td>Essay on Readings in Science Research (HS)</td>
<td>W</td>
<td>10</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
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<tbody>
<tr>
<td>862-0025-00L</td>
<td>Essay on Readings in Theoretical Philosophy (HS)</td>
<td>W</td>
<td>10</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

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<th>Lecturers</th>
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<tr>
<td>862-0027-00L</td>
<td>Essay on Readings in Practical Philosophy (HS)</td>
<td>W</td>
<td>10</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

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Objective: Writing this essays intents to become acquainted with methods, tools and concepts relevant for the students master thesis.

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<th>Hours</th>
<th>Lecturers</th>
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</thead>
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<tr>
<td>862-0029-00L</td>
<td>Essay on Readings in Literature and Culture (HS)</td>
<td>W</td>
<td>10</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

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<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>862-0031-00L</td>
<td>Essay on Readings in History of the Modern World (HS)</td>
<td>W</td>
<td>10</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>862-0035-00L</td>
<td>Essay on Readings in History and Philosophie of Mathematical Sciences (HS)</td>
<td>W</td>
<td>10</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract: One-to-one supervisions form the basis for an essay covering the paradigmatic texts studied over several semesters. This essay should also take recent research into account. The instructor will work one-to-one with the student to hone the skills and fundamental topics that are relevant for the Master's thesis.

Objective: One-to-one supervisions form the basis for an essay covering the paradigmatic texts studied over several semesters. This essay should also take recent research into account. The instructor will work one-to-one with the student to hone the skills and fundamental topics that are relevant for the Master's thesis.

Seminars

In the seminaries topics from the introductory courses are taught in more detail. Topics for essays are to be arranged with the teachers of the courses.

Research Colloquium

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>862-0004-15L</td>
<td>Research Colloquium Philosophy for Master Students and PhD (HS 2022)</td>
<td>W</td>
<td>2</td>
<td>1K</td>
<td>R. Wagner, M. Hampe, N. Mazouz, L. Wingert</td>
</tr>
</tbody>
</table>

For MAGPW and PhD students of D-GESS only.

Abstract: Ph.D. students, post docs, members of staff, and senior colleagues from other philosophy departments will report on their work in progress. Furthermore, promising new philosophical articles and parts of new philosophical books will be studied.

Objective: Ideas and arguments dealing with systematic problems especially in epistemology, ethics, political philosophy, and the philosophy of mind will be scrutinized and elaborated.

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

For PhD and postdoctoral students. Master students are welcome.

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment for the respective module at UZH. Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-
The fortnightly colloquium provides an ideal forum for Master and PhD students as well as postdoctoral researchers to familiarize themselves with current trends in global history. The slots are reserved for presentations by invited external scholars of the highest calibre.

Participating students will have an opportunity to follow high level debates in global history. By writing short reports and comments on two selected sessions they train the ability to summarize complex arguments and articulate their position in controversial debates.

Information about dates and program:
http://www.gmw.ethz.ch/studium.html

862-0088-11L Research Colloquium Science Studies (HS 2022) W 2 credits 1K M. Hagner

Abstract
Colloquium is designed for advanced and graduated students.

Objective
This colloquium is devoted to the introduction into the theory and practice of scientific work. The schedule can be found on the institute’s website - http://www.wiss.ethz.ch/en/teaching/

Prerequisites / notice
Lectures may be held either in English or German. Students receive 2 credit points for submitting a brief, written commentary on one of the presented topics (approx. 5 pages).

862-0089-11L Advanced Colloquium in Literary Studies (HS 2022) W 2 credits 1K A. Kilcher

Abstract
Colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.

Objective
The colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.

851-0551-20L Colloquium for Master and PhD Students History of Technology (HS 2022) W 2 credits 1K D. Gugerli

Abstract
Colloquium for master and doctoral students preparing a thesis in the history of technology.

Objective
Goals: to identify, discuss, and resolve methodological problems that emerge while elaborating a master or doctoral thesis.

Prerequisites / notice

851-0041-00L Research Colloquium for Practical Philosophy Does not take place this semester. W 2 credits 1K N. Mazouz

Abstract
Current topics of practical philosophy are discussed on the basis of texts and lectures.

Objective
Students are introduced to current research in the field of practical philosophy.

**Master’s Thesis**

The work on the master-thesis is supervised by one of the teachers that are allowed to offer tutorials for it, named in the Leitfaden.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>862-0500-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

A student is only permitted to commence the Master thesis if:

a. the Bachelor degree programme has been completed
b. any additional requirements for admission to the degree programme have been fulfilled
c. all credits have been acquired in the categories basic courses and major courses and at least 6 credits have been acquired in the category research colloquium

The Master's thesis gives a thorough historical, philological or philosophical analysis of a topic related to the experimental or formal sciences or to technology. It incorporates the relevant research literature on this topic as well as first attempts at original research.

The master thesis gives a thorough historical, philological or philosophical analysis of a topic related to the experimental or formal sciences or to technology. It incorporates the relevant research literature on this topic as well as first attempts at original research.
The course "Didactic Basics for Student Teaching Assistants" enhance Student Teaching Assistants (Student TAs) to develop knowledge, capability and confidence to effectively plan and teach courses and exercises. Participants get trained to think critically about students’ learning and create learning situations in which students are actively engaged.

**Objective**
In this course Student Teaching Assistants will ...
- reflect on their approach to teaching as well as their attitude towards teaching.
- understand the basics of teaching and learning in the context of their subject.
- consciously design the introduction of their course as well as the introduction of single teaching units.
- apply classroom assessment techniques as formative assessments to measure the current status of their students.
- develop a didactic concept according to the learning objectives.
- conduct interactive sequences as learning activities.
- give and get feedback from peers and self-reflect on their teaching practice.
- feel confident to use methods for active learning scenarios in their classes.

**Prerequisites / notice**
Self-paced online course: https://moodle-app2.let.ethz.ch/course/view.php?id=17417
Consolidation Workshops at the beginning of November (dates will be announced in the online course at the beginning of the semester)

**Coaching Students**
The course "Coaching Students" enhance Student Teaching Assistants (Student TAs) in their role as student coaches to develop basic knowledge about coaching methodology and the mindset of a coach.

**Objective**
In this course Student Teaching Assistants will ...
- understand the basics of coaching and the role as student coaches.
- develop the mindset of a coach and reflect on their attitude towards guiding student learning processes (individuals and teams).
- acquire coaching skills and build knowledge and know-how about coaching methods.
- design the coaching session and feel confident to use coaching methods.
- give and get feedback from peers and self-reflect on their coaching practice.

**Content**
The online course provides a range of relevant topics for developing teaching competences of Student Teaching Assistants:
- Overview about how learning works. Based on these fundamentals of learning participants reflect on their role as Student TAs to feel comfortable in their new role as a teacher.
- Plan an own lesson by introducing a class and locate it in the larger topic (methods: portal and informative introduction).
- Develop learning activities in order to activate students (active learning methods).
- Giving and also getting feedback. The participants integrate this topic also in their lesson plan.

While working through the online course, Student TAs have the chance to reflect, exchange ideas with peers and plan their own teaching accordingly so that they feel confident in their role.

**Prerequisites / notice**
Six double lessons with in-class activities (skills training):
05.10.2022 (16:15-18h)
12.10.2022 (16:15-18h)
19.10.2022 (16:15-18h)
26.10.2022 (16:15-18h)
02.11.2022 (16:15-18h)
09.11.2022 (16:15-18h)
All double lessons start at 4.15pm and finish by 6pm.
This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities.

Abstract
This course imparts a variety of teaching skills which will help Doctoral Teaching Assistants with their teaching tasks.

Objective
- discuss learning science and teaching techniques with peers.
- design the introduction of their course/lecture/exercise class.
- develop learning activities according to learning objectives.
- practice classroom assessment techniques in order to measure student learning.
- engage in peer feedback in order to improve own teaching.

Content
We will meet for the kick-off meeting online on the 3rd of October 2022 from 1-3 pm. You will get detailed information together with the invitation email in the first week of the semester. The online phase, where you work through 6 modules in the Moodle course page will end by the 11th of November 2022. We will meet on the 16 or 17th of November 22 for the Consolidation workshop. You will find more information on the course page in Moodle.

Prerequisites / notice
This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities (exercises, excursions, supervision of practicals, lectures, etc.) or those who will assume teaching tasks in the semester following the programme. No previous teacher training is required.

865-0008-00L Policy Evaluation and Applied Statistics

Z 3 credits 2G
I. Günther, K. Harttgen, K. Schneider

Abstract
This course introduces students to key methods for quantitative policy impact evaluation and covers the different stages of the research process. Acquired skills are applied in a self-selected project applying experimental methods. Students also learn how to perform simple statistical analyses with the statistical Software R.

Objective
- know strategies to test causal hypotheses using experimental methods and regression analysis.
- are able to formulate and implement a research design for a particular policy question and a particular type of data.
- are able to critically read and assess published studies on policy evaluation.
- are able to use the statistical software R for data analysis.
- can apply all the steps involved in a policy impact evaluation.

Content
Policy impact evaluation employs a wide variety of research methods, such as statistical analysis of secondary data, surveys or laboratory and field experiments. The course will begin with an overview of the various methodological approaches, including their advantages and disadvantages and the conditions under which their use is appropriate. It will continue with a discussion of the different stages of a policy impact evaluation, including hypothesis generation, formulating a research design, measurement, sampling, data collection and data analysis. For data analysis, linear regression models will be revised, with a focus on difference-in-difference methods, regression discontinuity design and randomized controlled trials used for policy evaluation. Students, who already have a solid background in these methods can skip these sessions.

Throughout the course, students will work on a self-selected project on a suitable topic. In addition, students will have to solve bi-weekly assignments.

865-0011-01L Water, Sanitation and Waste Management

Z 2 credits 2G
I. Günther, E. Tilley, C. Zurbrügg

Abstract
The course provides an overview of the links among sanitation, water supply, waste management and environmental and health aspects. It gives an understanding of the specific challenges and possible solutions in ensuring environmental services and illustrates their impact on the population and settlements.

Objective
- The participants are able to:
  - present the global situation and development trends in the sector of sanitation, water supply, waste management and for its main actors;
  - discuss the relationships between water supply, sanitation and health;
  - explain the principles of technologies for drinking water treatment, the management of sewage and waste, as well as appraise their strengths and weaknesses;
  - explain which sustainable concepts are implemented and how they can be inserted into the technical, institutional and social structures so that they are economically, ecologically and socially sustainable;
  - provide information where good professional resources are available.

Militray Studies

Literature
- Annen, H., Steiger, R. & Zwygart, U.: Gemeinsam zum Ziel, Huber, Frauenfeld 2004 (provided as pdf)
- Stadelmann, J.: Führung unter Belastung, Huber, Frauenfeld 1998 (provided as pdf)

The lecture is supported by a virtual learning environment containing relevant documents (presentations and texts) and information to further literature.

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Military History I (Without Exercises)  

**Abstract**

The purpose of the lecture is to outline the development of the armed forces (assets regarding manpower, technology and armament), the concepts of warfare and the actual warfare in the 19th and 20th century.

**Objective**

- Distinguish between military history as a subject and historiography as a way of describing events;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Based on the approach regarding revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Exemplify the issues regarding the evolution of the combat (First and Second World War, Vietnam War and Algerian War).

**Content**

The lecture first examines the bases of the science of (military) history. It focuses on how military history developed from war history, on specific similarities and differences between military history and general historiography, the different ways of dealing with history in Switzerland, Germany, France and in the Anglo-Saxon cultural area (different approaches) as well as on institutions which deal with military history such as universities, military academies, national and international commissions and associations etc.

The lecture is structured along the lines of the concept of "Military Revolution" and starts with the formation of modern, European armed forces after the Ottoman Empire reform in the 17th century. Based on the "Military Revolution" approach, the lecture examines the structural changes regarding the armed forces and the development of warfare from the 18th to the 20th century. Special emphasis will be put on how the battlefield was revolutionized due to the Napoleonic wars, the industrialization in the 19th century, the First World War, the mechanization and totalization during the Second World War and the period of the Cold War.

**Literature**


Strategic Studies I

**Abstract**

The lecture series treats high-impact strategic theory from antiquity to the present. The participants know how the understanding of strategy has evolved over time. They understand the interplay of strategy's basic components: ends, ways, means.

**Objective**

They know the most important classics of strategy and war theory, especially against their specific historical background. Based on the analysis of historical and contemporary examples, they are aware of the mismatch between declaration and implementation of any given strategy.

**Content**

The two-term lecture series treats classic texts of strategic studies from antiquity to the present. Term 1 covers the theories up until roughly 1900, term 2 treats the theories eversince. Theories are considered classic if they were prominent in their respective times and if they enjoyed a strong reception thereafter, be it in intellectual, academic debates or as guidelines for action (doctrine). Each out of some 50 theories is discussed in three steps: historical context, core elements and reception.

**Literature**

Peter Paret, Makers of Modern Strategy. From Machiavelli to the Nuclear Age, Princeton 1986.


**Taught competencies**

- Critical Thinking
- Self-awareness and Self-reflection

Military Sociology I

**Abstract**

Beside of the most important terms of sociology, demographic changes and the related value and structure change will be analysed. The second part focuses on organizational sociology. Thirdly, the course examines to which extent armed forces can be considered as organizations like any other and to which extent they constitute a special case from an organizational and normative point of view.

**Objective**

Recognize and explain current changes (social change) in modern society (individualisation, pluralisation); describe demographic changes in Switzerland; explain the structures of societies; define issues and fields of research in modern military sociology and explain the foundations of organisational sociology; explain the military in terms of organisational sociology and identify specific traits of the military as an organisation.

**Content**

Societal change; organizations as societal phenomena; aims, structures, environments of organizations; specific of the military as an organization; impacts of technological and societal changes on the armed forces in modern societies.

**Literature**

A reader with a set of texts will be handed out.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
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- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

853-0101-02L Defense Economics I Z 3 credits 2V M. M. Keupp

Abstract
In terms of structure and content, the event follows the lecturer's book "Militärökonomie" (Military Economics), which is available in two language versions:
- German language: ISBN 978-3-658-06146-3

Objective
* Recognizing parallels and contrasts between business and military thinking;
* Recognize and analyze planned economic systems;
* Understand the link between institutions, human action and economic results.

Content
The semester program of the course is divided into 14 modules of 90 minutes each, which combine lecture (teaching of analytical techniques) and exercise (application by means of concrete case studies).

The contents correspond to sections 1 to 2.2.5 of the above book. The following will be discussed:
1. fundamental military economic problems including historical introduction to the topic
2. the institutional foundations of a military organisation
3. the modern military as a planned economy system
4. actors and stakeholders in the system

Literature
ISBN 978-3-658-06146-3

ISBN 978-3-658-25287-8

Prerequisites / notice
none.

853-0033-00L Leadership I Z 3 credits 2V M. Holenweger, F. Demont

Abstract
The lectures "Leadership I" (WS) and "Leadership II" (SS) have been designed as a two-semester lecture series, but may also be followed independently of one another or in reverse order. "Leadership I" covers the following fields: leadership basics, leadership theories and leadership styles, the concept of leadership responsibility and the role of communication in practical leadership.

Objective
The aim of this lecture is to give students an introductory overview of relevant topics regarding leadership research and practice, thus enabling them to gain a deeper understanding of the leadership phenomenon. Students should understand different concepts of leadership in the complex interaction between individuals, groups, organisation, context and situation. They should be informed about the evolution of the understanding of mankind in relation to working processes and its impact on organizations and the understanding of leadership theory in the past 100 years. They should grasp the concept of leadership responsibility (leadership ethics) and be able to derive consequences for leadership in practical situations. They should recognize the fundamental importance of communication in leadership situations and receive input which enables them to communicate adequately in specific situations.

Specialized Continuing Education
Special internal ETH courses offered by LET and the Teaching Specialists.

Number Title Type ECTS Hours Lecturers
999-9999-99L EduApp Course E- 0 credits 1V+1U B. Volk

This course unit is not a genuine ETH course unit. It is used by LET and the Teaching Specialists for EduApp demonstration purposes.

Humanities, Social and Political Sciences (General Courses) - Key for Type

| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W  | Eligible for credits                 | Dr | Suitable for doctorate        |
| E- | Recommended, not eligible for credits | O  | Compulsory                    |

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### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
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<tr>
<td>V</td>
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</tr>
<tr>
<td>G</td>
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<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
First Year Core Courses

First Year Examinations

First Year Examinations Part 1

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0033-00L</td>
<td>Molecular Genetics and Cell Biology</td>
<td>O</td>
<td>5</td>
<td>5G</td>
<td>J. Corn, F. Allain, K. Köhler</td>
</tr>
</tbody>
</table>

Abstract This course teaches the basic principles of evolution, cell biology, molecular biology, genetics and developmental biology using the example of humans.

Objective
1. Students can explain the importance of evolution for the development of humans and diseases.
2. The students know the cell as the smallest unit of the body. They can explain how the functions of the cell are disturbed in certain diseases and where therapies intervene. They can describe the multiplication of cells in the body and show how errors in this multiplication can lead to diseases.
3. The students know DNA as the basis of life. They can explain how the DNA information is stored and how this information can be reproduced and protected from damage. They can describe how the information is read and translated into proteins. They can explain which mechanisms at the level of DNA, RNA and proteins can cause diseases.
4. Students can explain which technologies can be used to diagnose and treat diseases.
5. Students can explain how people differ genetically and know the molecular basis of these differences. They can explain how these differences can lead to diseases and why some of these differences do not affect diseases.
6. The students know the molecular causes of the most common hereditary diseases and can determine the probability of occurrence and transmission to offspring.
7. Students can explain the biochemical and molecular basis of human reproduction and know the basic principles of human embryonic development. The students can explain which mechanisms can be disturbed by a faulty development.

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1001-03L</td>
<td>General Chemistry (for HST)</td>
<td>O</td>
<td>6</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
</tbody>
</table>

Abstract
The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.

Objective
The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.

Literature
Weiterführende Literatur:
Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(english)

Taught competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility not assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management assessed

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0852-00L</td>
<td>Foundations of Computer Science</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>L. E. Fässler, M. Dahinden</td>
</tr>
</tbody>
</table>

Abstract
Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects.

Objective
The students learn to
- understand the role of computer science in science,
- to control computer and automate processes of problem solving by programming,
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

Content
1. The role of computer science in science
2. Introduction to Programming with Python
3. Modeling and simulations
4. Data management with lists and tables
5. Data management with a relational database
6. Introduction to Matrices

Lecture notes
All materials for the lecture are available at www.gdi.ethz.ch
Organic Chemistry I (for Biol./Pharm.Sc./HST)

Objective
Understanding the basic concepts and definitions of organic chemistry. Knowledge of the functional groups and classes of compounds that are important in biological systems. Foundations for the understanding of the relationship between structure and reactivity.

Content


Prerequisites / notice
This course is offered at the University of Zürich.

Lectures

Literature


## Eindimensionale diskrete Entwicklungen ##
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsraten
- Folgen und Grenzwerte

## Funktionen in einer Variablen ##
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

## Differentialrechnung (I) ##
- Veränderungsrate-geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

## Integralrechnung (I) ##
- Stammfunktionen
- Integrationstechniken

## Gewöhnliche Differentialgleichungen (I) ##
- Qualitative Beschreibung an Beispielen: Beschränkt, Logistisch, Gompertz
- Stationäre Lösungen
- Lineare DGL 1. Ordnung
- Trennung der Variablen

## Lineare Algebra ##
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

Lecture notes
In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:
* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature
Siehe auch Lernmaterial > Literatur

**L. Papula**
Mathematik für Ingenieure und Naturwissenschaftler, 2 Bände; Springer Verlag Vieweg.
Via ETHZ-Bibliothek:

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände:
Einführung in die Analysis, Einführung in die Lineare Algebra;
Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF
auch als [pdf](https://people.math.ethz.ch/~blatter/linalg.pdf)

Prerequisites /
notice

## Übungen und Prüfungen ##
+ Die Übungsaufgaben (inkl. Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltung.
+ Es wird erwartet, dass Sie mindestens 75 % der wöchentlichen Serien bearbeiten und zur Korrektur einreichen.
+ Der Prüfungsstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

### Second and Third Year Core Courses

#### Examination Blocks

##### Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
Basic knowledge of the anatomy and physiology of tissues, of the embryonal and postnatal development, the sensory organs, the neuromuscular system, the cardiovascular system and the respiratory system.

Objective
Basic knowledge of human anatomy and physiology and basics of clinical pathophysiology.
The lecture series provides a short overview of human anatomy and physiology

Anatomy and Physiology I (fall term):
Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system

Anatomy and Physiology II (spring term):
digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.

Prerequisites / notice
Requirements: 1st year, scientific part.
Part of the course is read and checked in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0293-00L</td>
<td>Mathematics III</td>
<td>5</td>
<td>O</td>
<td>3V+2U</td>
<td>A. Caspar, N. Hungerbühler</td>
<td></td>
</tr>
</tbody>
</table>

Abstract
Vertiefung der mehrdimensionalen Analysis mit Schwerpunkt in der Anwendung der partiellen Differentialgleichungen, Vertiefung der Linearen Algebra und Einführung in die Systemanalyse und Modellbildung.

Objective
Die Studierenden
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allfällig explizit berechnen: diskret/kontinuierlich in Zeit, Ebene und Raum.
- können Modelle und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.

Content
- SIR-Modelle
- Pocken-Modell
Lineare Modelle
- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix
Fourier-Reihen
- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen
Nichtlineare Modelle
- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra
Partielle Differentialgleichungen
- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie
Laplace-Transformation
- Definition und Notation
- Rechengrößen
- Anwendungsbeispiele

Lecture notes
Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Literature
- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Prerequisites / notice
Vorlesungen Mathematik I/II

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Type</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0643-13L</td>
<td>Statistics II</td>
<td>3</td>
<td>O</td>
<td>2V+1U</td>
<td>J. Dambon</td>
<td></td>
</tr>
</tbody>
</table>

Abstract
Vertiefung von Statistikmethoden. Nach dem detailierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

Objective
The course is an introduction to classical physics, with special focus on applications in medicine.

### 1. Introduction to Medical Technology

**Objective**
Obtain an understanding of basic concepts in classical physics and their application (using mathematical pre-knowledge) to the solution of simple problems, including certain applications in medicine.

**Content**
General introduction; Positron-Emission-Tomography as appetizer, including ionising radiation; kinematics of a point mass; dynamics of a point mass (Newton's axioms and forces); physical work, power and energy; conservation of linear and angular momentum; oscillations and waves; mechanics of a rigid body; fluid mechanics; introduction to electricity.

**Lecture notes**
Will be distributed at the start of the semester.

**Prerequisites / notice**
Voraussetzung Mathematik I-II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin) / Mathematik-Lehrveranstaltungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)

### Examination Block C

**only offered in spring semester.**

#### Individual Subjects and Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0019-00L</td>
<td>Laboratory Course in Medical Technology</td>
<td>O</td>
<td>2</td>
<td>2P</td>
<td>J. G. Snedeker</td>
</tr>
<tr>
<td>Abstract</td>
<td>This practical course is designed to give students hands on experience in CAD, FEM, product optimization, mechanical load testing, software development and hardware utilization in robotics.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The course aims at teaching and solidifying following topics: CAD FEM Product optimization Mechanical testing Software development Hardware usage in robotics</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>The course is aimed at improving the students knowledge on certain topics such as programming in python and biomechanics, but also teaches new skills such as using CAD software, FEM and mechanical testing. The course is split into 6 sessions, which will be completed in groups. The students will be assigned to groups at the beginning of the semester. 4 of the experiments will be geared towards the use case of designing a bone plate to bridge a critical size gap of a femur. The experiments are therefore 1) using CAD to reconstruct the initial condition and the bone plate 2) running a FEM in order to analyze the performance of the bone plate 3) with the knowledge of the FEM, optimizing the bone plate and 4) testing of the designed bone plate, the bone plate will be 3D printed. The remaining 2 experiments will 1) focus on programming a robotic arm used in rehabilitation engineering and 2) on the hardware usage of the robotic arm including force sensors and EMG.</td>
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<tr>
<td>Lecture notes</td>
<td>Each of the 6 sessions has its own tutorial and will be handed out to the students. Only motivation and curiosity is required.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Only for BSc HST students. Students from other degree programmes please contact: <a href="mailto:hcooper@ethz.ch">hcooper@ethz.ch</a></td>
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<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0002-01L</td>
<td>Product Design in Medical Engineering</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>S. J. Ferguson</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course will provide insight into various aspects of medical device design such as patient needs assessment, product specification, research and technical design, validation, regulatory affairs and clinical evaluation.</td>
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<tr>
<td>Objective</td>
<td>The goal of this lecture series is to enable the students to (i) identify the principal functional requirements for a medical device, (ii) understand the mechanical properties of natural tissues and synthetic biomaterials, (iii) to apply this information and a basic knowledge of mechanics in the calculation of implant performance, (iv) to develop a plan for the pre-clinical evaluation and regulation of a new device.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td><a href="https://moodle-app2.let.ethz.ch/course/view.php?id=180">https://moodle-app2.let.ethz.ch/course/view.php?id=180</a></td>
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### Focus Courses

#### Human Movement Sciences and Sports

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Taylor, R. List</td>
</tr>
<tr>
<td>Abstract</td>
<td>Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.</td>
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<tr>
<td>Content</td>
<td>Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.</td>
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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0207-00L</td>
<td>Exercise Physiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>C. Spengler, F. Gabe Beltrami, R. M. Rossi</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health.</td>
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</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1091 of 2345
The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors.

History of Exercise Physiology, research methods, fibertype heterogeneity and its functional significance, neural control of muscle force, molecular and cellular mechanisms of muscle adaptation to resistance, endurance and stretching exercise, interindividual variability in the response to training, cardiorespiratory and metabolic responses to acute and chronic exercise, sex differences relevant to exercise performance, exercise in hot and cold environment, children and adolescents in sport and exercise, exercise at altitude and depth, aging and exercise performance, exercise for health, exercise in the context of disease.

This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenary discussions.

The course will cover the following topics:

- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthetics, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Parasports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

#### Medical Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**

History of BME and the role of biomedical engineers. Ethical issues related to BME.

- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals. Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.

**Lecture notes**

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

**Prerequisites / notice**

No specific requirements, BUT

- ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

376-0021-00L Materials and Mechanics in Medicine

W 4 credits 3G M. Zenobi-Wong, J. G. Snedeker

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
course website on Moodle

Literature

Academic Press

376-1714-00L Biocompatible Materials

W 4 credits 3V K. Maniura, M. Rottmar, M. Zenobi-Wong

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

(available online via ETH library)

376-1220-00L Rehabilitation and Inclusion

W 3 credits 2G R. Riener

Abstract
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

Objective
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenar discussions.
The course will cover the following topics:
- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Parasports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

### Molecular Health Sciences

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>

**Abstract**

Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH. Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics.

**Content**

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**

Scripts and additional material will be provided during the semester.

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**

Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**

- Introduction and historical background
- Innate and adaptive immunity. Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

**Literature**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**Taught competencies**

- Subject-specific Competencies: Concepts and Theories assessed, Techniques and Technologies assessed
- Method-specific Competencies: Analytical Competencies not assessed, Decision-making assessed, Media and Digital Technologies not assessed, Problem-solving assessed, Project Management not assessed
- Social Competencies: Communication not assessed, Cooperation and Teamwork not assessed, Customer Orientation not assessed, Leadership and Responsibility not assessed, Self-presentation and Social Influence not assessed, Sensitivity to Diversity assessed, Negotiation not assessed
- Personal Competencies: Adaptability and Flexibility not assessed, Creative Thinking not assessed, Critical Thinking assessed, Integrity and Work Ethics not assessed, Self-awareness and Self-reflection assessed, Self-direction and Self-management assessed

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>376-1348-00L</td>
<td>Cellular Ageing</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>G. Shivashankar</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1094 of 2345
Abstract
Cells undergo major functional alterations as we age. In this course, we will discuss the basic molecular and cell biological mechanisms of cellular ageing. We will also discuss diseases related to cellular ageing and current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Objective
- Basic molecular and cell biological mechanisms of cellular ageing;
- Diseases related to cellular ageing;
- Current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Content
Lecture-1: Hallmarks of cellular ageing
Lecture-2: Cellular microenvironment & extra-cellular matrix
Lecture-3: Cell morphometric changes & cytoskeletal remodeling
Lecture-4: Proteostasis
Lecture-5: Mitochondrial dysfunction
Lecture-6: Endo-membrane signaling
Lecture-7: Nuclear signaling & epigenetic alternations
Lecture-8: Chromatin remodeling & gene expression
Lecture-9: Genomic integrity
Lecture-10: Ageing cell secretome and cellular homeostasis
Lecture-11: Diseases associated with cellular ageing
Lecture-12: Cellular rejuvenation strategies
Lecture-13: Therapeutic interventions to cellular ageing
Lecture-14: Concluding lecture

Neurosciences

Number Title Type ECTS Hours Lecturers
376-0007-01L Advanced Neuroanatomy and Neurophysiology W 4 credits 3G M. Willecke, S. Meissner, D. P. Wolfer

Abstract
Advanced knowledge of anatomy and physiology of the nervous system.

Objective
The course equips students with advanced knowledge of the anatomical structure and function of the most important structures of the central nervous system. They will understand pathophysiological mechanisms and identify explanations for the occurrence of specific symptoms in neurological diseases. They will also be able to apply their knowledge to describe the mechanism of action of drugs. In addition, they learn the most important methods for analyzing the functions of the nervous system and will be able to use this knowledge to evaluate experimental data.

Content
1. Anatomie: Wie ist das zentrale Nervensystem aufgebaut?
2. Motorische Kontrolle: Welche Strukturen sind an willkürlichen und unwillkürlichen Bewegungen beteiligt?
3. Sensorische, somatosensorische und sensomotorische Integration: Wie werden Informationen aus verschiedenen Systemen integriert und vom Gehirn interpretiert?
4. Höhere Hirnfunktionen: Welche Spezialisierungen ermöglichen es uns zu sprechen und Emotionen und Gefühle zu verarbeiten?

Prerequisites / notice
Während der Grundvorlesung (Anatomie und Physiologie 1) haben Sie bereits viele der in dieser Vorlesung behandelten Themen kennengelernt, allerdings nicht so detailliert. In dieser Vorlesung wird der Stoff der Grundvorlesung vertieft und erweitert. Es wird vorausgesetzt, dass Sie die in der Grundvorlesung besprochenen Inhalte bereits kennen. Der Stoff aus der Grundvorlesung wird nur teilweise repetiert.

Die Lektionen zur Neurophysiologie enthalten Einheiten des Selbststudiums. Dabei bearbeiten Sie Arbeitsaufträge in einem Polybook, um ein konzeptuelles Verständnis für die behandelten Themen zu entwickeln.

Taught competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

376-1305-00L Development of the Nervous System (University of Zurich)

Abstract
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.
### Objective

On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development
- apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

**Key skills**

On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

### Content

The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental disorders will be discussed.

### Lecture notes

Must be downloaded from OLAT: [https://www.olat.uzh.ch/olat/dmz/as BIC344](https://www.olat.uzh.ch/olat/dmz/as BIC344)

### Literature

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

### Prerequisites / notice

BIO142 Developmental Biology, BIO143 Neurobiology

### Course 376-1305-01L: Neural Systems for Sensory, Motor and Higher Brain Functions

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<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>G. Schratt, J. Bohacek, R. Fiore, R. Polania, W. von der Behrens, J. Winterer, further lecturers</td>
</tr>
</tbody>
</table>

**Enrolment to this course unit only possible at ETH. No enrolment to module BIC343 at UZH.**

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**Abstract**

The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

**Objective**

The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.

**Content**

The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.

**Literature**

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle / OLAT.

### Course 551-0309-00L: Concepts in Modern Genetics

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<tbody>
<tr>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
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</table>

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**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics.

**Content**

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**

Scripts and additional material will be provided during the semester.

### Bachelor Studies (Programme Regulations 2017)

#### Second Year Compulsory Courses

#### Examination Blocks

#### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
</table>

**Abstract**

Basic knowledge of the anatomy and physiology of tissues, of the embryonal and postnatal development, the sensory organs, the neuro-muscular system, the cardiovascular system and the respiratory system.

**Objective**

Basic knowledge of human anatomy and physiology and basics of clinical pathophysiology.

**Content**

The lecture series provides a short overview of human anatomy and physiology

Anatomy and Physiology I (fall term):
- Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system
- Anatomy and Physiology II (spring term):
  - digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.

**Prerequisites / notice**

Requirements: 1st year, scientific part.
Part of the course is read and checked in English.

| 401-0293-00L | Mathematics III | O    | 5    | 3V+2U | A. Caspar, N. Hungerbühler |

**Abstract**

Vertiefung der mehrdimensionalen Analyse mit Schwerpunkt in der Anwendung der partiellen Differentialgleichungen, Vertiefung der linearen Algebra und Einführung in die Systemanalyse und Modellbildung.
Die Studierenden

- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenfalls explizit berechnen: diskret/­kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.

Einführung Modellbildung

- SIR-Modelle
- Pocken-Modell

Lineare Modelle

- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen

- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle

- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen

- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Laplace-Transformation

- Definition und Notation
- Rechenregeln

Vorlesungen Mathematik I/II

Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler


Abstract

Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfrähigkeit mit der Statistiksoftware R.

Objective


Examination Block 3

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-0643-13L | Statistics II | O | 3 credits | 2V+1U | J. Dambon

Abstract

Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfrähigkeit mit der Statistiksoftware R.

Objective


Focus Courses

"Physik für Mediziner, Biologen, Pharmazeuten"; von Alfred Trautwein, Uwe Kreibig, Jürgen Hütermann; De Gruyter Verlag.

Voraussetzung Mathematik I-II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin) / Mathematik-Lehrveranstaltungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)
### Molecular Health Sciences

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
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<td><strong>Information for UZH students:</strong></td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<td></td>
<td>This course focuses on the concepts of classical and modern genetics and genomics.</td>
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<td><strong>Content</strong></td>
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<td>The topics include classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Scripts and additional material will be provided during the semester.</td>
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### Human Movement Science and Sport

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<tbody>
<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Taylor, R. List</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>Movement- and sports biomechanics deals with the attributes of the human body and its link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics relevant to biomechanics are investigated.</td>
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### Exercise Physiology

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<tbody>
<tr>
<td>376-0207-00L</td>
<td>Exercise Physiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>C. Spengler, F. Gabe Beltrami, R. M. Rossi</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health.</td>
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<td><strong>Objective</strong></td>
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<td>The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>History of Exercise Physiology, research methods, fibertype heterogeneity and its functional significance, neural control of muscle force, molecular nad cellular mechanisms of muscle adaptation to resistance, endurance and stretching exercise, interindividual variability in the response to training, cardiorespiratory and metabolic responses to acute and chronic exercise, sex differences relevant to exercise performance, exercise in hot and cold environment, children and adolescents in sport and exercise, exercise at altitude and depth, aging and exercise performance, exercise for health, exercise in the context of disease.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Online material is provided during the course.</td>
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### Rehabilitation and Inclusion

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</thead>
<tbody>
<tr>
<td>376-1220-00L</td>
<td>Rehabilitation and Inclusion</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. Rieder</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal &amp; regulatory aspects, disability policy, and inclusion.</td>
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<td><strong>Objective</strong></td>
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<td>With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modular way using interactive tools and organizing group/plenary discussions.</td>
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<td><strong>Content</strong></td>
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<td>The course will cover the following topics:</td>
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<tr>
<td></td>
<td>1. Introduction: definition, historical and legal background, role of the UNO, WHO, ICRC</td>
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<td></td>
<td>2. Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments</td>
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<td>3. Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy</td>
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<td>4. Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)</td>
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<td>5. Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy</td>
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<td>6. Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.</td>
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<td>7. Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.</td>
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<td>8. Accessibility: national and international aspects of accessibility</td>
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<td>9. Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV</td>
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<td>10. Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design</td>
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<td>11. Parasports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon</td>
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<td>12. Policy: health, social equal opportunity, disability</td>
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<td>13. Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability</td>
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<td>14. Prevention: primary and secondary prevention, social prevention</td>
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</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1098 of 2345
Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at “Lernmaterialien”

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Taught competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: not assessed
  - Decision-making: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed
- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: assessed
- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: assessed

376-1348-00L Cellular Ageing

W 3 credits 2V G. Shivashankar

Abstract
Cells undergo major functional alterations as we age. In this course, we will discuss the basic molecular and cell biological mechanisms of cellular ageing. We will also discuss diseases related to cellular ageing and current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Objective
- Basic molecular and cell biological mechanisms of cellular ageing;
- Diseases related to cellular ageing;
- current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Content
Lecture-1: Hallmarks of cellular ageing
Lecture-2: Cellular microenvironment & extra-cellular matrix
Lecture-3: Cell morphometric changes & cytoskeletal remodeling
Lecture-4: Proteostasis
Lecture-5: Mitochondrial dysfunction
Lecture-6: Endo-membrane signaling
Lecture-7: Nuclear signaling & epigenetic alternations
Lecture-8: Chromatin remodeling & gene expression
Lecture-9: Genomic integrity
Lecture-10: Ageing cell secretome and cellular homeostasis
Lecture-11: Diseases associated with cellular ageing
Lecture-12: Cellular rejuvenation strategies
Lecture-13: Therapeutic interventions to cellular ageing
Lecture-14: Concluding lecture

376-1348-00L Biomedical Engineering

W 4 credits 3G J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.
In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.
### Content


### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>not assessed</td>
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<td></td>
<td>Project Management</td>
<td>not assessed</td>
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</tbody>
</table>

### Social Competencies

| Communication | not assessed |
|              |              |
| Cooperation and Teamwork | not assessed |
| Customer Orientation | not assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity | not assessed |
| Negotiation | not assessed |

### Personal Competencies

| Adaptability and Flexibility | not assessed |
|                            |              |
| Creative Thinking | not assessed |
| Critical Thinking | not assessed |
| Integrity and Work Ethics | not assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and Self-management | not assessed |

### Prerequisites

No specific requirements, BUT HEST and BIOL students will have to learn a lot of new words related to biochemistry, biology and medicine, while ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

### Literature

- Handouts are deposited online (moodle).

### Prerequisites / notice

- Handouts and references therin.
- (available online via ETH library)

### Handouts and references therin.


### Autumn Semester 2022

- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.
- Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.
- Handouts and references therin.
- (available online via ETH library)

### Lecture notes

- Introduction to Biomedical Engineering
  by Enderle, Banchard, and Bronzino
  AND moodle page of the course.
Advanced Neuroanatomy and Neurophysiology

M. Willecke, S. Meissner, D. P. Wolfer

**Abstract**

The course equips students with advanced knowledge of the anatomical structure and function of the most important structures of the central nervous system. They will understand pathophysiological mechanisms and identify explanations for the occurrence of specific symptoms in neurological diseases. They will also be able to apply their knowledge to describe the mechanism of action of drugs. In addition, they learn the most important methods for analyzing the functions of the nervous system and will be able to use this knowledge to evaluate experimental data.

**Objective**

With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenary discussions.

**Content**

The course will cover the following topics:

- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Paraports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

**Neurosciences**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-0007-01L</td>
<td>Advanced Neuroanatomy and Neurophysiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Willecke, S. Meissner, D. P. Wolfer</td>
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</tbody>
</table>

**Abstract**

Advanced knowledge of anatomy and physiology of the nervous system.

**Objective**

The course equips students with advanced knowledge of the anatomical structure and function of the most important structures of the central nervous system. They will understand pathophysiological mechanisms and identify explanations for the occurrence of specific symptoms in neurological diseases. They will also be able to apply their knowledge to describe the mechanism of action of drugs. In addition, they learn the most important methods for analyzing the functions of the nervous system and will be able to use this knowledge to evaluate experimental data.

**Content**

1. Anatomie: Wie ist das zentrale Nervensystem aufgebaut?
2. Motorische Kontrolle: Welche Strukturen sind an willkürlichen und unwillkürlichen Bewegungen beteiligt?
3. Sensorische, somatosensorische und sensomotorische Integration: Wie werden Informationen aus verschiedenen Systemen integriert und vom Gehirn interpretiert?
4. Höhere Hirnfunktionen: Welche Spezialisierungen ermöglichen es uns zu sprechen und Emotionen und Gefühle zu verarbeiten?

**Prerequisites / notice**


**Taught competencies**

- Subject-specific Competencies: Concepts and Theories assessed,
  - Techniques and Technologies not assessed
- Method-specific Competencies: Analytical Competencies assessed,
  - Decision-making assessed,
  - Media and Digital Technologies not assessed,
  - Problem-solving assessed,
  - Project Management not assessed
- Social Competencies: Communication not assessed,
  - Cooperation and Teamwork not assessed,
  - Customer Orientation not assessed,
  - Leadership and Responsibility not assessed,
  - Self-presentation and Social Influence not assessed,
  - Sensitivity to Diversity not assessed,
  - Negotiation not assessed
- Personal Competencies: Adaptability and Flexibility not assessed,
  - Creative Thinking not assessed,
  - Critical Thinking not assessed,
  - Integrity and Work Ethics not assessed,
  - Self-awareness and Self-reflection not assessed,
  - Self-direction and Self-management not assessed

**Development of the Nervous System (University of Zurich)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

**UZH Module Code:** BIO344

Mind the enrolment deadlines at UZH: [https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html](https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html)

**Abstract**

The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.
Objective
On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills
On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz as BIOC344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
BIO142 Developmental Biology, BIO143 Neurobiology

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<th>ECTS</th>
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<tbody>
<tr>
<td>376-1305-01L</td>
<td>Neural Systems for Sensory, Motor and Higher Brain Functions Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIOC343 at UZH. Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html</a></td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>G. Schratt, J. Bohacek, R. Fiore, R. Polania, W. von der Behrens, J. Winterer, further lecturers</td>
</tr>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIOC348 at UZH. Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html</a></td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
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Electives

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<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0575-01L</td>
<td>Signals and Systems</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>A. Carron</td>
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<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>B. Nelson</td>
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Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical micro robots

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

The lecture will be taught in English.

**151-0917-00L** Mass Transfer

**Abstract**
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

**Objective**
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

**Literature**

**Prerequisites / notice**
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

**227-0045-00L** Signals and Systems I

**Abstract**

**Objective**
Introduction to mathematical signal processing and system theory.

**Content**

**Literature**

**Prerequisites / notice**
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

**327-0113-00L** Foundations of Materials Science I

**Abstract**
The basic physical concepts for the description of materials are taught, partly in self-study, and applied in exercises. Basic atomic and macroscopic concepts (e.g. phase diagrams, phase transformations, response functions) are introduced through examples. Selected topics are deepened in classroom lectures.

**Objective**
Students are able to
- name the basic concepts of materials science. (remember, 1)
- describe simple relations between atomic structure and macroscopic properties. (understand, 2)
- calculate basic material-specific quantities. (apply, 3)
- read and interpret phase diagrams, material characteristic (e.g. stress-strain) diagrams and Ashby plots (analyse, 4)

**Content**
Atomic structure
Crystalline structure and defects
Thermodynamics, phase diagrams and phase transformations
Diffusion
Mechanical and thermal properties of materials

**Literature**
Main textbook:
William D. Callister, Jr., David G. Rethwisch
Materials Science and Engineering - An Introduction

Alternatives:
Milton Ohring
Engineering Materials Science

James F. Shackelford
Introduction to Materials Science for Engineers

**376-0130-00L** Laboratory Course in Exercise Physiology

**Abstract**
Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

**Objective**
Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of physical activity and climatic influences. Learn fundamental assessment techniques of the muscular system, the cardio-respiratory system and of whole-body performance, learn scientifically correct data analysis and interpretation of results. Insight into today's Sports Medicine.

**Content**
Laboratory course:
Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test, dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.
Teaching materials for the individual lectures are provided to the students via moodle. In addition to particularly relevant public health topics and major social health risks, the course teaches the thinking and approach of the


Comprehension for development and changes of sports from the ancient world to the presence.

**Ein Skript für die aktuelle Veranstaltung wird abgegeben.**

Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle.

**This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.**

**Content**

- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

**Literature**


**Prerequisite:**

Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)

Desirable:

Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)
### 376-1127-00L Sociology of Sport

**W** 2 credits  
**2V** R. Bürgi

**Abstract**
These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.

**Objective**
The lectures set out to:
- present the different dimensions, functions and interrelationships of present-day sport  
- provide an introduction to the central theories and models of (sport) sociology  
- show how far sport reflects society and how it changes and becomes more differentiated in the process  
- take current examples to highlight the sociological view of sport.

**Content**
- Sport and social change: developments and trends  
- The economy and the media: dependencies, consequences, scandals  
- Social inequalities and distinctions: gender differences and group behavior  
- Conflicts and politics: sports organizations, doping, violence  
- Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or chemical exposure and resulting in a tumor. They are able to list important cancer-inducing agents and explain the respective mechanism of action. They have knowledge of significant risk factors for cancer diseases. They are confronted with the basics of toxicology and they can explain the principle of the most common therapeutic strategies.  

**Lecture notes**
Selected materials for the lecture are available on the Moodle platform.

**Literature**


**Taught competencies**

| Subject-specific Competencies | Concepts and Theories | assessed  
|-------------------------------|-----------------------|---------
| Method-specific Competencies  | Analytical Competencies | assessed  
| Social Competencies           | Sensitivity to Diversity | assessed  
| Personal Competencies         | Critical Thinking | assessed

### 376-1581-00L Cancer: Fundamentals, Origin and Therapy

**W** 2 credits  
**2G** H. Nägeli

**Abstract**

**Objective**
Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or chemical exposure and resulting in a tumor. They are able to list important cancer-inducing agents and explain the respective mechanism of action. They have knowledge of significant risk factors for cancer diseases. They are confronted with the basics of toxicology and they can explain the principle of the most common therapeutic strategies.

**Content**
The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process. Classes of chemical compounds that induce cancer are discussed as well as the reactive metabolites that may be built from. Covalent binding to DNA is discussed and different types of mutations resulting thereof. A selection of proto-oncogenes and tumor suppressor genes is presented. Their function will be discussed as well as the changes which are found in these genes in tumor cells, starting from single nucleotide exchanges up to large deletions.

The reason for genetic predisposition to cancer will be discussed as well as cancer relevant aspects of cell cycle regulation. The role of tumor microenvironments and phenomenons like angiogenesis and metastasis are presented as well as the mechanisms that protect the genome from mutagenic damage. Further subjects address old and new strategies of cancer treatment. Personalised cancer treatment.

**Lecture notes**
Handouts with reproductions of all presented transparencies will be distributed.

**Literature**


**Additional information**
additional information is given during the lecture.

**Prerequisites / notice**
The lecture requires an active participation of the students. All students will participate in individual or group work focussing on specific subject of the lecture. Students will have ample time for preparation during lecture time.
Students learn the assessments to plan an exercise-therapy-treatment. They are able to prepare a therapy-session. They are able to use them. They're able to integrate biological and medical basics.

### Basics of Exercise Therapy

A: diagnostic, anamnesis, diagnostic of movement and function, assessments in exercise therapy, diagnostic of experience and behavior in relation to movement.

B: biological-medical basics, pathophysiological Basics (internal, orthopedic and psychological deseases).

C: didactic knowledge, Reha-didactic

### Content

- Grundlagen der Diagnostik, Anamnese, Bewegungsdiagnostik, Funktionsdiagnostik
- Sport- und Bewegungstherapeutische Testverfahren
- Motorische Basisdiagnostik
- Diagnostik bewegungsbezogenen Erlebens und Verhaltens
- Biologisch-medizinische Grundlagen
- Biomechanik (v.a. Gelenken), Pathophysiologische Grundlagen, Modelle der Methodik und Didaktik, Lektionsplanung

Lecture notes

wird vor Semesterbeginn elektronisch zur Verfügung gestellt

Literature

- Schüle / Huber: Grundlagen der Sporttherapie, Deutscher Ärzteverlag, Köln 2012
- Deimel et al.: Neue aktive Wege in Prävention und Rehabilitation, Deutscher Ärzteverlag, Köln 2007

Prerequisites / notice

90% of the lections students must be present.

open-book-test in the last sessions at 20.12.2017
Does not take place this semester. Number of participants limited to 30.

Possible from the 5th semester on. Requirement: 376-1715-00L "Introduction to Exercise Therapy" passed.

Abstract
Communication skills and methods of psychoregulation applied to the area of Exercise and Sports Therapy.

Objective
The students are able to plan, lead through and evaluate conversations with patients. The students are familiar with a specific method of psychoregulation. The participants know different aspects of relationship formation (therapist/client) in therapeutic work.

Content
Communication and conversation: client-centered forms of conversation in theory and practice Psychoregulative Methods: Theoretical and practical insight into various psychoregulative methods

Prerequisites
The courses "Exercise and Sports Therapy 1 and 2" have been completed successfully. A minimum of 90% of attendance if used as credits towards CAS SVGS.

One seminar day in an institution/company specialized in reintegration of clients into the workforce.

Abstract
Communication skills and methods of psychoregulation applied to the area of Exercise and Sports Therapy.

Objective
The students are able to plan, lead through and evaluate conversations with patients. The students are familiar with a specific method of psychoregulation. The participants know different aspects of relationship formation (therapist/client) in therapeutic work.

Content
Communication and conversation: client-centered forms of conversation in theory and practice Psychoregulative Methods: Theoretical and practical insight into various psychoregulative methods

Lecture notes
Documents will be distributed two weeks before lecture.

Prerequisites
The courses "Exercise and Sports Therapy 1 and 2" have been completed successfully. A minimum of 90% of attendance if used as credits towards CAS SVGS.

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Content
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Prerequisites
The courses "Exercise and Sports Therapy 1 and 2" have been completed successfully. A minimum of 90% of attendance if used as credits towards CAS SVGS.

One seminar day in an institution/company specialized in reintegration of clients into the workforce.
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective: Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content: Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes: No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature: Mainly based on original literature, a detailed list will be distributed during the lecture

Tufted competencies: Subject-specific Competencies
- Concepts and Theories
- Assessed
- Techniques and Technologies
- Assessed

Method-specific Competencies
- Analytical Competencies
- Assessed
- Problem-solving
- Assessed

Social Competencies
- Communication
- Assessed
- Cooperation and Teamwork
- Assessed

Personal Competencies
- Self-awareness and Self-reflection
- Assessed
- Self-direction and Self-management
- Assessed

Literature:

**535-0230-00L Medicinal Chemistry I**
- W
- 2 credits
- 2V
- J. Hall

Abstract: The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective: Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content: Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

Lecture notes: Will be provided in parts before each individual lecture.

Literature:

Prerequisites / notice: Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.

**535-0521-00L Pharmacology and Toxicology I**
- W
- 3 credits
- 2V
- U. Quitterer, J. Abd Alla

Abstract: This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

Objective: The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

Content: The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicity, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

Lecture notes: A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

Literature:

Klaus Aktories, Ulrich Förstermann, Franz Hofmann, Klaus Starke.
Allgemeine und spezielle Pharmakologie und Toxikologie.
Urban & Fischer (Elsevier, München)

The classic textbook in Pharmacology:

Goodman and Gilman’s The Pharmacological Basis of Therapeutics
Laurence Brunton, Bjorn Knollmann, Randa Hilal-Dandan.
ISBN-10: 1259584739

or 14th Edition (expected Dec. 2022)

Voraussetzungen: Abschluss Grundstudium

**535-0810-00L Gene Technology**
- W
- 2 credits
- 2G
- K. Eyer, J. Scheuermann

Abstract: The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

Objective: The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the-art of the methods of applications, and are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

Data: 18.08.2022 12:39
Autumn Semester 2022
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Methods and Techniques:
- Recombinant DNA technology
- Next generation sequencing methods, sequencing of genomes
- CRISPR technology

Application to human biology:
- Functional genomics/transcriptomics
- Principles of cancer, genetic diseases
- Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and characterisation of complex cellular functions requires a combination of approaches such as biochemical, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytokoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

### Content

I) Genomics and transcriptomics

Methods and Techniques:
- Recombinant DNA technology
- Next generation sequencing methods, sequencing of genomes
- CRISPR technology

Application to human biology:
- Functional genomics/transcriptomics
- Principles of cancer, genetic diseases
- Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

II) Proteomics

Methods and Techniques:
- Protein cloning and expression
- The antibody molecule
- Measurement and determination of biomolecular interactions
- Protein characterization and engineering
- Modifications and radioactive labelling

Application to human biology:
- Protein therapeutics
- Proteomic approaches for identification of novel disease-related targets and biomarkers

III) Drug discovery: Protein-based libraries

- Immune repertoire mining
- Display and selection technologies
  1. antibody phage display
  2. other polypeptide display technologies
  3. small-molecules display: DNA-encoded chemical libraries

Lecture notes:
The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### Literature

- Janeway’s ImmunoBiology, by Kenneth Murphy (9th Edition; Garland).

- Chapters 1 - 11 of the Janeway’s ImmunoBiology, by Kenneth Murphy (9th Edition).

- [www.garlandscience.com](http://www.garlandscience.com)

### Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.
### Course Overview

**Course Code:** 701-0901-01L  
**Course Name:** ETH Week 2022: Urban Futures

**Objective:**
ETH Week is an innovative one-week course designed to foster critical thinking and creative learning. Students from all departments as well as professors and external experts will work together in interdisciplinary teams. They will develop interventions that could play a role in solving some of our most pressing global challenges. In 2022, ETH Week will focus on the topic of urban development.

- **Domain-specific knowledge:** Students have immersed knowledge about a certain complex, societal topic which will be selected every year. They understand the complex system context of the current topic, by comprehending its scientific, technical, political, social, ecological and economic perspectives.

- **Analytical skills:** The ETH Week participants are able to structure complex problems systematically using selected methods. They are able to acquire further knowledge and critically analyse the knowledge in interdisciplinary groups and with experts and the help of team tutors.

- **Design skills:** The students are able to use their knowledge and skills to develop concrete approaches for problem-solving and decision making to a selected problem statement, critically reflect on these approaches, assess their feasibility, to transfer them into a concrete form (physical model, prototypes, strategy paper, etc.) and to present this work in a creative way (role-plays, videos, exhibitions, etc.).

- **Self-competence:** The students are able to plan their work effectively, efficiently and autonomously. By considering approaches from different disciplines they are able to make a judgment and form a personal opinion. In exchange with non-academic partners from business, politics, administration, non-governmental organisations and media they are able to communicate appropriately, present their results professionally and creatively and convince a critical audience.

- **Social competence:** The students are able to work in multidisciplinary teams, i.e. they can reflect critically on their own discipline, debate with students from other disciplines and experts in a critical-constructive and respectful way and can relate their own positions to different intellectual approaches. They can assess how far they are able to actively make a contribution to society by using their personal and professional talents and skills as "Change Agents".

- **Remote collaboration competence:** The students work in a hybrid setting blending physical and virtual communication and collaboration methods and tools. They experience the potential and limitations of remote collaboration.

**Content:**
The week is mainly about problem-solving and design thinking applied to the complex world of health and well-being. During ETH Week students will have the opportunity to work in small interdisciplinary groups, allowing them to critically analyse both their own approaches and those of other disciplines, and to integrate these into their work.

While deepening their knowledge about sustainable urban development, students will be introduced to various methods and tools for generating creative ideas and understanding how different people are affected by each part of the system. In addition to lectures and literature, students will acquire knowledge via excursions into the real world, empirical observations, and conversations with researchers and experts.

A key attribute of ETH Week is that students are expected to find their own problems, rather than just solve the problem that has been handed to them.

### Prerequisites / Notice

No prerequisites. Programme is open to Bachelor and Masters from all ETH Departments. All students must apply through a competitive application process at www.ethz.ch/ethweek. Participation is subject to successful selection through this competitive process.

### Taught Competencies

<table>
<thead>
<tr>
<th>Competency</th>
<th>Taught Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<tr>
<td>Negotiation</td>
<td>assessed</td>
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<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td>Creative Thinking</td>
<td>assessed</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

### Courses Details

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Prerequisites / Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-2120-00L</td>
<td>Consumer Behaviour I</td>
<td>2</td>
<td>Mr. Siegrist, A. Bearth, A. Berthold</td>
</tr>
<tr>
<td>752-4005-00L</td>
<td>Food Microbiology I</td>
<td>3</td>
<td>Mr. Loesner</td>
</tr>
</tbody>
</table>
The course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeorhesis are emphasized.

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance.

The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeorhesis are emphasized.

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The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).
Language Courses
see Science in Perspective: Language Courses ETH/UZH

Sports Practice
Sport Practical Basic Education
Sport Practical Advanced Education
Assessments

Health Sciences and Technology Bachelor - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
### Educational Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
<tr>
<td></td>
<td>This lecture is only apt for students who intend to enrol in the programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about learning in childhood and adolescence.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
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<td></td>
<td>Thematische Schwerpunkte: Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenserwerbs; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<td>Folien werden zur Verfügung gestellt.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td></td>
<td></td>
<td>This lecture is only apt for students who intend to enrol in the programs &quot;Lehrplaus&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
</tr>
<tr>
<td>851-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W D2)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>U. Markwalder, S. Maurer, S. Peteranderl-Rüschoff</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 20.</td>
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<td>The successful participation in EW1 (&quot;Human Learning&quot;) and EW2 (&quot;Designing Learning Environments for School&quot;) is recommended, but not a mandatory prerequisite.</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>In this class, students will learn concepts and skills for coping with psychosocial demands of teaching</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td></td>
<td>(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).</td>
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<td>(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).</td>
</tr>
<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td></td>
<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
</tr>
<tr>
<td>851-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
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<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td>Number of participants limited to 30.</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>This focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
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<td></td>
<td>- Understanding of research methods used in the empirical human sciences</td>
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<td>- Getting to know intelligence tests</td>
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<td></td>
<td></td>
<td></td>
<td>- Understanding findings relevant for education</td>
</tr>
<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>C. M. Thurn, T. Braas, P. Edelsbrunner</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
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<td>Abstract</td>
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<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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</table>
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

**Prerequisites / notice**
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

### Subject Didactics and Professional Training

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-8001-00L</td>
<td>Didactics of Health Sciences and Technology I</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>S. Maurer, S. Sinistaj</td>
</tr>
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<td></td>
<td><em>Only for Health Sciences and Technology TC students.</em></td>
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**Abstract**
Enrolment at the earliest possible with the lecture 851-0240-00L “Human Learning.”

**Objective**
- Students know how to prepare, conduct and reflect a single lesson based on educational requirements.
- Students take the learning goals as a starting point considering previous knowledge as well as the professional environment and the ambitions of the learners.
- Students apply the basic didactic techniques of their subject area in a sensible way and know how to appropriately arrange the phases of learning.
- Students know how to simplify and present complex technical contents of their subject area.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

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**376-8008-00L Teaching Internship Including Examination Lessons**

*Health Sciences and Technologie*

Only for Health Sciences and Technology TC students.

The teaching internship can just be visited if all other courses of TC are completed.

Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

**Abstract**

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

**Objective**

- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

**376-8011-00L Mentored Work Subject Didactics Health Sciences and Technologie**

Only for Health Sciences and Technology TC students.

**Abstract**

The mentored paper is designed to bring together the findings from the FD1 and the FD2. By using various teaching techniques and methods a semester plan, which is based on various curricula will be elaborated for a given topic.

**Objective**

1. The students have planned a curriculum for a semester course.
2. Students reflect on formative and summative ways such a teaching unit to examine and implement parts of it.
3. The students have implemented parts of the semester curriculum.
4. The students deal with the question to what extend teaching techniques, teaching methods but also sequences of self-study must be involved in the planning.

---

**Health Sciences and Technology TC - Key for Type**

| O  | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W  | Eligible for credits | Dr | Suitable for doctorate |

**Key for Hours**

| V  | lecture |
| G  | lecture with exercise |
| U  | exercise |
| S  | seminar |
| K  | colloquium |
| P  | practical/laboratory course |
| A  | independent project |
| D  | diploma thesis |
| R  | revision course / private study |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Health Sciences and Technology Master
► Major in Human Movement Science and Sport
► Compulsory Courses

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<tr>
<th>Number</th>
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<th>Type</th>
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<tbody>
<tr>
<td>376-0300-00L</td>
<td>Translational Science for Health and Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfrum</td>
</tr>
</tbody>
</table>

**Abstract**
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basic features of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

**Objective**
After completing this course, students will be able to understand:
- Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)

**Content**
What is translational science and what is it not?
- How to identify need?
  - Disease concepts and consequences for research
  - Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
  - Ethical considerations including ethics application
  - Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources
- How to measure success?
  - Outcome variables
  - Improving the translational process
- Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.

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<tbody>
<tr>
<td>376-0302-01L</td>
<td>GCP Basic Course (Modules 1 and 2)</td>
<td>O</td>
<td>1 credit</td>
<td>1G</td>
<td>G. Senti, C. Fila, R. Grossmann</td>
</tr>
</tbody>
</table>

**Abstract**
The basic course in “Good Clinical Practice” (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

**Objective**
Students will get familiar with:
- Key Ethics documents
- (In)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related related personal data

**Content**
Module 1:
- Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
- Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

► Electives
►► Electives Courses I

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>376-0221-00L</td>
<td>Methods and Concepts in Human Systems Neuroscience and Motor Control</td>
<td>W</td>
<td>4 credits</td>
<td>3P</td>
<td>F. Gabe Beltrami</td>
</tr>
</tbody>
</table>

**Abstract**
This course provides hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (nerve/brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students read scientific material, set up experiments, perform measurements in the lab, analyse data, apply statistics and write short reports or essays.

**Objective**
This course will prepare students for experimental work as it is typically done during the master thesis. The goal is to gain hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (for example peripheral nerve stimulation, electrical and magnetic brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students will learn how to perform small scientific projects in this area. Students will work individually or in small groups and solve scientific problems which require them to perform measurements in human participants, extract relevant readouts from the data, apply appropriate statistics and interpret the results. They will also be required to write small essays and reports and they will get feedback on their writing throughout the course.

**Prerequisites / notice**
Students are required to have successfully completed the course “Neural control of movement and motor learning” and to have basic knowledge of applied statistics.

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<tr>
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<tbody>
<tr>
<td>376-0223-00L</td>
<td>Advanced Topics in Exercise Physiology</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>C. Spengler, G. D'Hulst, F. Gabe Beltrami</td>
</tr>
</tbody>
</table>

**Abstract**
In this course, students read, present and discuss seminal publications in the area of exercise physiology. The focus lies on critical analysis of scientific content, conceptual as well as ethical aspects of publications. Students are trained in the most common scientific presentation techniques such as oral and poster presentations.

Data: 18.08.2022 12:39
Autumn Semester 2022
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The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with measurement and modeling of the human movement during daily activities and in a clinical environment. To be provided by the individual lecturers, at their discretion.

Core texts for this course are:

- Introduction to Physical Activity for Health, including sedentary behavior
- Physical activity epidemiology; concepts principles and approaches
- Physical activity and all cause morbidity and mortality
- Physical activity and chronic disease; Coronary heart disease, diabetes, bone health, cancer and obesity
- Physical activity and brain health
- Physical activity and sedentary behavior recommendations
- Population prevalence of physical activity and sedentary behavior
- Physical activity policies
- Physical activity assessment

This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling with regards to human movement.

### Elective Courses II

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
</tr>
</tbody>
</table>

Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Lecture notes: Lecture notes and handouts


Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on understanding the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Historical and role of biomedical engineers. Ethical issues related to BME.

Medical optics: Optical components and systems used in hospitals.

Biomaterials and their medical applications.

Image analysis and computer vision. Unitary transformations. Color and texture.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Introduction to Biomedical Engineering

by Enderle, Banchard, and Bronzino

Prerequisites / notice

No specific requirements, BUT

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

The course language is English.
Microscopy Training TEM I - Introduction to TEM

The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

Practicals:
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping
- Practice on real-world samples and report results
- Practice on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Prerequisites / notice
No mandatory prerequisites.

327-2126-00L

Microscopy Training TEM I - Introduction to TEM

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP0.html).

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract

The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

Objective

Understanding of:
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to:
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

Content

Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

363-0301-00L

Work Design and Organizational Change

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective

- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content

During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- Electron sources, electron lenses and probe formation
- Beam/specimen interaction, image formation, image contrast and imaging modes.
- Sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by business acumen to succeed in this new environment. This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.

The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterium
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

### Literature
A list of required readings will be provided at the beginning of the course.

### Prerequisites / notice
The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.

### Content

**Objective**

- Know effects of work design on competence, motivation, and well-being
- Understand links between design of individual jobs and work processes
- Know basic processes involved in systematic organizational change
- Understand the interaction between organization and technology and its impact on organizational change
- Understand relevance of work design for company performance and strategy
- Know and apply methods for analyzing and designing work

**Content**

The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.

### Schedule

- **15'**: Introduction
- **15'**: Discussion related to topic (in groups)
- **20'**: Q&A with (guest) lecturer
- **10'**: Plenary discussion
- **60'**: (Guest) lecture

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

### Semester assignment

Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

### See course website

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis. To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A). Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science. Material will be provided on Moodle and eColab.

Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

376-0130-00L Laboratory Course in Exercise Physiology  W  4 credits  4P  C. Spengler
Number of participants limited to 48.

HST: Possible from the 5th semester on.

Abstract
Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

Objective
Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of physical activity and climatic influences. Learn fundamental assessment techniques of the muscular system, the cardio-respiratory system and of whole-body performance, learn scientifically correct data analysis and interpretation of results. Insight into today's Sports Medicine.

Content
Laboratory course.
Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test), dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.

Prerequisites / notice
Desirable: Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)

376-0203-00L Movement and Sport Biomechanics  W  4 credits  3G  B. Taylor, R. List

Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

Objective
Students are able to describe the human body as a mechanical system. They can analyse and describe human movement according to the laws of mechanics.

Content
Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

376-0207-00L Exercise Physiology  W  4 credits  3G  C. Spengler, F. Gabe Beltrami, R. M. Rossi

This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health.

Objective
The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors.

Content
History of Exercise Physiology, research methods, fibertype heterogeneity and its functional significance, neural control of muscle force, molecular and cellular mechanisms of muscle adaptation to resistance, endurance and stretching exercise, interindividual variability in the response to training, cardiorespiratory and chronic metabolic responses to exercise, performance in hot and cold environment, children and adolescents in sport and exercise, exercise at altitude and depth, aging and exercise performance, exercise for health, exercise in the context of disease.

Lecture notes Literature
Online material is provided during the course.

Wird in der Vorlesung bekannt gegeben.

Prerequisites / notice
Anatomy and Physiology I - II

376-0208-00L Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects  W  3 credits  2G  O. Bar-Nur, K. De Bock

Prerequisites:
Laboratory Course in Molecular Biology (376-0006-02L)
Number of Participants limited to 16

Abstract
The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimuli. In this course, the students will acquire insights into the molecular aspects of muscle biology and exercise, in addition to gaining hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

Objective
The objective of this course is to introduce students to current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Content
The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

Topic 1: Molecular pathways that control muscle stem cell self-renewal and differentiation
Topic 2: Genome engineering to correct genetic mutations that cause muscle diseases
Topic 3: Muscle fiber composition, force production and insulin sensitivity
Topic 4: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experiences and an evaluation session.

For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group’s research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants the following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

i. Group 1: tissue culture, isolation of muscle stem cells via FACS, differentiation of muscle stem cell into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, Immunofluorescence.
ii. Group 2: tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers. Immunofluorescence and PCR.
iii. Group 3: ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, immunofluorescence and western blot.
iv. Group 4: tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers. Western blot.

Prerequisites / notice
Prerequisites: 376-0006-02L Laboratory Course in Molecular biology

376-0816-00L Applied Human Research Project Management W 4 credits 3G C. Lustenberger, M. Altermatt

Number of participants limited to 30.

Abstract
This course equips the students with several key principles such as good clinical practice, ethical study requirements, reproducible data management and effective oral, graphical, and written communication to design and manage good quality, ethically sound human research studies and represents a 101-toolkit of transferable research management skills/digital tools.

Objective
The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

• Create/select well-founded research hypothesis and study designs for a specific research topic
• Apply universal good clinical practice guidelines in future research projects
• Integrate well-documented data management and open science principles into future research projects
• Integrate principles of effective communication in speaking, writing and graphical illustrations of future research ideas/output

Content
The course will cover the following topics:

• Introduction to different study designs and ethical requirements thereof in Switzerland
• Introduction to literature search and searching platforms
• How to collect and sort publications/ keep up to date on research topic
• Inputs on critically evaluating papers
• How to pre-define study requirements to "future-proof" the research (hypothesis, sample size definition, pre-registration)
• Correct conduction of fundamental human research procedures (e.g., screening, consent process, CRF) and identification/prevention of deviations and emergencies (e.g., SAE/AE, protocol violation, research misconduct)
• Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metafiles)
• FAIR principles and open science
• Design principles and free digital tools for graphical illustrations
• Effective summarizing of research output/topic in an abstract and pitch presentation

376-1033-00L History of Sports W 2 credits 2V M. Gisler

Abstract
Comprehension for development and changes of sports from the ancient world to the present. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day.

Objective
Understanding for the development and adaptation of sports from the ancient world to present times.

Content

Literature

376-1107-00L Sport Pedagogy W 2 credits 2V C. Herrmann

Abstract
The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on "pedagogical-psychological aspects of competence development in the context of a multi-perspective physical education".

Objective
Development of pedagogical-psychological competences for the optimisation of future teaching activities.
376-1117-00L  
**Sport Psychology**  
**W** 2 credits  
2V  
R. Bürgi  

**Abstract**  
This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.  

**Objective**  
Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students' expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.  

**Content**  
Main Topics  
- Introduction to sport psychology  
- Cognitions in sports: mental rehearsal and mental training  
- Emotions and stress  
- Motivation: goal-setting in sports  
- Career and career transition in elite sport  
- Coach-Athlete-Interaction  
- Psychological aspects of sport-injury rehabilitation  
- Group dynamics in sport  

**Literature**  

376-1127-00L  
**Sociology of Sport**  
**W** 2 credits  
2V  
R. Bürgi  

**Abstract**  
These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.  

**Objective**  
The lectures set out to:  
- present the different dimensions, functions and interrelationships of present-day sport  
- provide an introduction to the central theories and models of (sport) sociology  
- show how far sport reflects society and how it changes and becomes more differentiated in the process  
- take current examples to highlight the sociological viewpoint of sport.  

**Content**  
Sport and social change: developments and trends  
- The economy and the media: dependencies, consequences, scandals  
- Social inequalities and distinctions: gender differences and group behavior  
- Conflicts and politics: sports organizations, doping, violence  

**Literature**  

376-1151-00L  
**Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging**  
**W** 3 credits  
2V  
C. Ewald  

**Abstract**  
Recently, several start-up companies are aiming to translate basic molecular findings into new drugs/therapeutic interventions to slow aging or post-pone age-related diseases (e.g., Google founded Calico or Craig Venter's Human Longevity, Inc.). This course will teach students the basic skill sets to formulate their own ideas, design experiments to test them and explains the next steps to translate these problems.  

**Objective**  
The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention. Learning objectives include:  
1. Evaluate the current problem of our aging population, the impact of age-related diseases and current strategies to prevent these age-dependent diseases.  
2. Analyse/compare current molecular/genetic strategies that address these aging problems.  
3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.  
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.  

**Content**  
Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.  

**Prerequisites / notice**  
No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.  

376-1176-00L  
**Wearable and Mobile Technologies of the Future - Focus on Sports and Health**  
**W** 4 credits  
3G  
C. Menon, C. Ahmadizadeh, M. Elgendi  

**Abstract**  
This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.  

**Objective**  
The lectures set out to:  
- present the different dimensions, functions and interrelationships of present-day sport  
- provide an introduction to the central theories and models of (sport) sociology  
- show how far sport reflects society and how it changes and becomes more differentiated in the process  
- take current examples to highlight the sociological viewpoint of sport.  

**Content**  
Sport and social change: developments and trends  
- The economy and the media: dependencies, consequences, scandals  
- Social inequalities and distinctions: gender differences and group behavior  
- Conflicts and politics: sports organizations, doping, violence  

**Literature**  

376-1176-00L  
**Wearable and Mobile Technologies of the Future - Focus on Sports and Health**  
**W** 4 credits  
3G  
C. Menon, C. Ahmadizadeh, M. Elgendi  

**Abstract**  
This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.  

**Objective**  
The lectures set out to:  
- present the different dimensions, functions and interrelationships of present-day sport  
- provide an introduction to the central theories and models of (sport) sociology  
- show how far sport reflects society and how it changes and becomes more differentiated in the process  
- take current examples to highlight the sociological viewpoint of sport.  

**Content**  
Sport and social change: developments and trends  
- The economy and the media: dependencies, consequences, scandals  
- Social inequalities and distinctions: gender differences and group behavior  
- Conflicts and politics: sports organizations, doping, violence  

**Literature**  
Abstract
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Objective
Objective 1:
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2:
Acquire skills to design novel non-invasive technologies for sport and health.

Content
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

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376-1177-00L Human Factors I
W 3 credits 2V M. Menozzi Jäckli, R. Huang, M. Siegrist

Abstract
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.

Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brochures, checklists, key articles etc. are uploaded in ILIAS

376-1179-00L Applications of Cybernetics in Ergonomics
W 1 credit 1U M. Menozzi Jäckli, Y.-Y. Hedinger Huang, R. Huang

Abstract
Cybernetics systems have been studied and applied in various research fields, such as for applications in ergonomics. Topics discussed in this lecture (man-machine-interaction, performance in multi-modal interactions, quantification in gestalt principles for the use in product development, information processing) are deepened with exercises conducted at our labs.

Objective
To learn and practice cybernetics principles in interface designs and product development.

Content
- Fitt's law applied in manipulation tasks
- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection
- Accommodationvergence crosslink function
- Cross-link models in neurobiology- the ocular motor control system
- Human performance in optimization of production lines

Literature

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions
W 3 credits 2V R. Riener, O. Lamberty

Abstract
Rehabilitation Engin is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Content

Introduction, problem definition, overview
- Rehabilitation of visual function
  - Anatomy and physiology of the visual sense
  - Technical aids (glasses, sensor substitution)
  - Retina and cortex implants
- Rehabilitation of hearing function
  - Anatomy and physiology of the auditory sense
  - Hearing aids
  - Cochlea Implants
- Rehabilitation and use of kinesthetic and tactile function
  - Anatomy and physiology of the kinesthetic and tactile sense
  - Tactile/haptic displays for motion therapy (incl. electrical stimulation)
  - Role of displays in motor learning
- Rehabilitation of vestibular function
  - Anatomy and physiology of the vestibular sense
  - Rehabilitation strategies and devices (e.g. BrainPort)
  - Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Rehabilitation of vegetative functions
  - Cardiac Pacemaker
  - Phrenic stimulation, artificial breathing aids
  - Bladder stimulation, artificial sphincter
  - Brain stimulation and recording
- Brain stimulation and recording
  - Cardiac Pacemaker
  - Phrenic stimulation, artificial breathing aids
  - Bladder stimulation, artificial sphincter

Literature

Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice

Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

376-1353-00L Nanostructured Materials Safety W 2 credits 1V P. Wick

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1125 of 2345
Students will learn to import, process and graphically present experimental data using the MATLAB computing environment. Both the data and the methods of analysis will be typical for experiments in Human Movement Science (i.e. kinematics, kinetics and electromyography).

Objective
Students will acquire the ability to independently load, plot, and process kinematic, kinetic and electromyographical data using the MATLAB computing environment.

Content
Drawbacks of Excel; Possibilities in MATLAB; Import of several data formats; Plot of one and more signals; Removing of an offset and filtering of data based on self-written functions; Normalisation and parametrisation of data; Reliability; Interpolation, Differentiation and Integration in MATLAB.

Literature
During the lecture, several electronically available MATLAB introductions are indicated. Course-specific scripts will be provided by the lecturer.

Prerequisites / notice
A Laptop with MATLAB installed (v2009 or higher) and wireless internet access is mandatory. Two students can share a laptop if necessary. A MATLAB student version can be obtained at Stud-IDES for free.

### 376-1661-00L Ethics of Life Sciences and Biotechnology

**Abstract**
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

**Objective**
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Plot solutions to ethical challenges and dilemmas.

**Content**
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

### 376-1714-00L Biocompatible Materials

**Abstract**
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degeneration products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**
Handouts are deposited online (moodle).

**Literature**

(available online via ETH library)

Handouts and references therin.

### 376-1720-00L Application of MATLAB in the Human Movement Sciences

**Abstract**
Students will learn to import, process and graphically present experimental data using the MATLAB computing environment. Both the data and the methods of analysis will be typical for experiments in Human Movement Science (i.e. kinematics, kinetics and electromyography).

**Objective**
Students will acquire the ability to independently load, plot, and process kinematic, kinetic and electromyographical data using the MATLAB computing environment.

**Content**
Drawbacks of Excel; Possibilities in MATLAB; Import of several data formats; Plot of one and more signals; Removing of an offset and filtering of data based on self-written functions; Normalisation and parametrisation of data; Reliability; Interpolation, Differentiation and Integration in MATLAB.

**Literature**
During the lecture, several electronically available MATLAB introductions are indicated. Course-specific scripts will be provided by the lecturer.

**Prerequisites / notice**
A Laptop with MATLAB installed (v2009 or higher) and wireless internet access is mandatory. Two students can share a laptop if necessary. A MATLAB student version can be obtained at Stud-IDES for free.

### 376-1722-00L Spinal Cord Injury and Exercise

**Prerequisite:** Anatomy and Physiology
Abstract
Intensive discussion concerning complications of a spinal cord injury and their consequences on trainability and exercise performance of persons sitting in a wheelchair. Overview on the clinical application of exercise testing as well as on the implementation of sport scientific findings to optimise performance of individuals with spinal cord injury in rehabilitation and elite sports.

Objective
Knowledge of the pathophysiology and the concomitant complications of a spinal cord injury and the consequences for physical exercise and trainability during rehabilitation as well as in recreational and elite sport.

Content
The following issues will be discussed: Epidemiology and etiology of spinal cord injury; complications and consequences of spinal cord injury; trainability/exercise physiology and spinal cord injury; history and organisation of wheelchair sports; elite sport and spinal cord injury

Literature
General literature:
H.G. Koch, V. Geng
Querschnittlähmung verständlich erklärt (Band 1 und Band 2)
Selbstverlag Manfred-Sauer-Stiftung und Schweizer Paraplegiker-Vereinigung
ISBN 978-3-00-069888-0 (Band 1) und 978-3-00-069889-7 (Band 2)

G.A. Zäch, H. G. Koch
Paraplegie - ganzheitliche Rehabilitation
Karger-Verlag, 2006
ISBN 3-8055-7980-2

V. Goosey-Tolfrey
Wheelchair sport: A complete guide for athletes, coaches and teachers
Human Kinetics, 2010

Y.C. Vanlandewijck, W.R. Thompson
The Paralympic Athlete
Wiley-Blackwell, 2011
ISBN 978-1-4443-3404-3

Liz Broad
Sports Nutrition for Paralympic Athletes, Second Edition
CRC Press 2019

Y.C. Vanlandewijck, W.R. Thompson
Training and Coaching the Paralympic Athlete
ISBN 978-1-119-04433-8

Prerequisites / notice
Voraussetzung: Vorlesung Anatomie/Physiologie besucht!

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

376-1723-00L Big Data Analysis in Biomedical Research W 4 credits 2V+2U E. Araldi, M. Ristow
Number of participants limited to 20.

Abstract
Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data.

Objective
This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and machine learning approaches. For the final assessment, students will conduct an independent data analysis project based on a biomedical problem of their choosing and using publicly available population-based biomedical datasets.

Content
While learning the programming skills needed to manipulate and visualize the data, participants will learn the statistical and modeling approaches for big data analysis. The course will cover:
• Basis of Python programming and UNIX;
• High performance computing;
• Manipulation and cleaning of large datasets with Pandas;
• Visualization tools (Matplotlib, Seaborn);
• Machine learning and numerical libraries (SciPy, NumPy, Statsmodels, Scikit-Learn);
• Statistical analysis and modeling of big data, and applications to biomedical datasets (statistical learning, distributions, linear and logistic regressions, principal component analysis, clustering, classification, time series analysis, tree-based methods, predictive models).

Prerequisites / notice
Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.
Systems Biology of Metabolism

Colloquium in Biomechanics

376-1974-00L

W 2 credits 2K


Abstract
Current topics in biomechanics presented by speakers from academia and industry.

Objective
Getting insight into actual areas and problems of biomechanics.

376-1985-00L

Trauma Biomechanics

Colloquium in Biomechanics

W 4 credits 2V+1U

K.-U. Schmitt, M. H. Muser

Abstract
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

Objective
Introduction to the basic principles of trauma biomechanics.

Content
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

Lecture notes
Handouts will be made available.

Literature

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

376-2017-00L

Biomechanics of Sports Injuries and Rehabilitation

Colloquium in Biomechanics

W 3 credits 2V

K.-U. Schmitt, J. Goldhahn

Abstract
This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.

Objective
Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

Content
This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanics that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

Lecture notes
Handouts will be made available.

Literature

Prerequisites / notice
A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

376-2019-00L

Applied Movement Analysis

Colloquium in Biomechanics

W 2 credits 2G

P. Schütz, to be announced

Abstract
Based on examples from sports science, practical training and movement therapy, different methods of movement analysis are applied and compared.

Objective
Students are able to assess human movements using various methods of movement analysis. They learn to systematically analyse movements by structured observation and to apply scientific methods according to the situation. They use modern technology as well as their own perception and experience.

Content
During the lecture students get acquainted with different scientific and practical methods of functional and biomechanical movement analysis.

Based on concrete examples, these methods will be applied and compared. The examples range from sport, everyday movement to therapy, such as ball sports, gymnastics/acrobatics, gait/running and strength training.

In the first phase of the lecture, the different approaches are presented and applied. In the process, current technical devices will be used. In a second phase, individual projects are worked out in small teams. The projects will be discussed, presented and graded.

Lecture notes
Class material will be distributed using the moodle platform.

551-1153-00L

Systems Biology of Metabolism

Colloquium in Biomechanics

W 4 credits 2V

U. Sauer, N. Zamboni, M. Zampieri

Abstract
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content
The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes
Script and original publications will be supplied during the course.

Prerequisites / notice
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

752-3105-00L

Physiology Guided Food Structure and Process

Colloquium in Biomechanics

W 3 credits 2V

E. J. Windhab.
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware of how epidemiological facts are used in prevention, practice and politics.

Therefore the objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures.

The students will be exposed to this interplay all along the GI tract, including taste, aroma and texture perception, swallowing mechanics and gastro intestinal digestion with an engineering or physical sciences angle.

### 752-6105-00L Epidemiology and Prevention

**Abstract**
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions, and to improved population health.

**Objective**
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware of how epidemiological facts are used in prevention, practice and politics.

**Content**
The module Epidemiology and prevention follows an overall framework that describes the process of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

**Taught competencies**

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<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
<td>Communication</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<tr>
<td>Critical Thinking</td>
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</tbody>
</table>

**Taught competencies**

<table>
<thead>
<tr>
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<tbody>
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<td>Analytical Competencies</td>
</tr>
<tr>
<td>Decision-making</td>
<td></td>
</tr>
</tbody>
</table>

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**Lecturers**

- M. Puhan
- R. Heusser

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### 752-6151-00L Public Health Concepts

**Abstract**
The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

**Objective**
At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

**Content**
Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, iodine/PK nutrition).

**Lecture notes**
Handouts are provided to students in the classroom.

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**Lecturers**

- R. Heusser

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### 752-6403-00L Nutrition and Performance

**Abstract**
The course introduces basic concepts of the interaction between nutrition and exercise performance.

**Objective**
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

**Content**
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

**Literature**
Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

**Prerequisites / notice**
General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

---

**Major in Human Health, Nutrition and Environment**

### Compulsory Courses

**Number**

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1701-00L</td>
<td>Human Health, Nutrition and Environment: Term Paper</td>
<td>O</td>
<td>6 credits</td>
<td>13A</td>
</tr>
</tbody>
</table>

**Abstract**
Writing of a review paper of scientific quality on a topic in the domain of Human Health, Nutrition and Environment based on critical evaluation of scientific literature.

**Objective**
- Acquisition of knowledge in the field of the review paper
- Assessment of original literature as well as synthesis and analysis of the findings
- Practising of academic writing in English
- Giving an oral presentation with discussion on the topic of the review paper

---

Data: 18.08.2022 12:39

Autumn Semester 2022
Translational Science for Health and Medicine

Objective
After completing this course, students will be able to understand:
- Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)
- What is translational science and what is it not?
- How to identify need?
- Disease concepts and consequences for research
  - Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources
- How to measure success?
- Outcome variables
- Improving the translational process
- Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences
- Positive and negative examples will be illustrated by distinguished guest speakers.

Content
The course will cover the major 'Human Health, Nutrition and Environment' covering 'Public Health', 'Infectious Diseases', 'Nutrition and Health' and 'Environment and Health'.

Lecture notes
Guidelines will be handed out in the beginning.

Literature
Literature will be identified based on the topic chosen.

376-0300-00L

Translational Science for Health and Medicine

Abstract
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

Objective
After completing this course, students will be able to understand:
- Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)
- What is translational science and what is it not?
- How to identify need?
- Disease concepts and consequences for research
  - Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources
- How to measure success?
- Outcome variables
- Improving the translational process
- Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences
- Positive and negative examples will be illustrated by distinguished guest speakers.

Content
The course covers the main methods used in Bioinformatics. It starts by revising Linear Models (Regression, ANOVA) and then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

Objective
After this course students should know how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Lecture notes
The course will cover the major 'Human Health, Nutrition and Environment' covering 'Public Health', 'Infectious Diseases', 'Nutrition and Health' and 'Environment and Health'.

Literature
Literature will be identified based on the topic chosen.

376-0302-01L

GCP Basic Course (Modules 1 and 2)

Abstract
The basic course in “Good Clinical Practice” (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

Objective
Students will get familiar with:
- Key Ethics documents
- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Content
Module 1:
Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

Electives

Elective Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0629-00L</td>
<td>Applied Biostatistics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Tanadini</td>
</tr>
</tbody>
</table>

Abstract
This course covers the main methods used in Bioinformatics. It starts by revising Linear Models (Regression, ANOVA), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

Objective
After this course students should know how to:
- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Bioinformatics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid “biological” conclusions

Content
This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model selection, residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

Prerequisites / notice
The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommend to view the online R course "etutoR".

752-6105-00L

Epidemiology and Prevention

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1130 of 2345
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication

Personal Competencies
- Creative Thinking
- Critical Thinking

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, iodine/PH nutrition).

Handouts are provided to students in the classroom.

<p>|</p>
<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

This course provides a detailed understanding of:
- development of T and B cells
- the dynamics of a immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Obtain a detailed understanding of:
- the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naïve B cells to antibody producing plasma cells and memory B cells,
- Optimization of B cell responses by intelligent design of new vaccines

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&not=edittingon=1

Immunology I and II recommended but not compulsory

<table>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
</tbody>
</table>

Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

Papers will be assigned and downloaded from a web page announced during the lecture.

<table>
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</thead>
<tbody>
<tr>
<td>701-1471-00L</td>
<td>Ecological Parasitology</td>
<td>W</td>
<td>3 credits</td>
<td>1V+1P</td>
<td>J. Jokela, C. Vorburger</td>
</tr>
</tbody>
</table>

A minimum of 6 students is required that the course will

Number of participants limited to 20.
Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research.

Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
5. Human macroparasites (schistosomiasis, malaria).

Practical exercises:
1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

Prerequisites / notice
The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

701-1703-00L Evolutionary Medicine for Infectious Diseases

Number of participants limited to 35.

Waiting list will be deleted on 30.09.2022.

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:

Schmid Hempel 2011 Evolutionary Parasitology
Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.

- Legal and protection issues related to functional foods

- Industrial biotechnology of flavor and taste development

- Safety of food cultures and probiotics

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

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<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>376-1353-00L</td>
<td>Nanostructured Materials Safety</td>
<td>W</td>
<td>2 credits</td>
<td>1V</td>
<td>P. Wick</td>
</tr>
</tbody>
</table>

Objectives:
- To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.
- To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.
- The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.
- There is no script. Powerpoint presentations will be made available on-line to students.
- To be provided by the individual lecturers, at their discretion.

Prerequisites / notice: This lecture requires strong basics in microbiology.

Module: Environment and Health

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>376-0300-00L</td>
<td>Translational Science for Health and Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfrum</td>
</tr>
</tbody>
</table>

Objective:
- After completing this course, students will be able to understand:
  - Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)
  - What is translational science and what is it not?
  - How to identify need?
  - Disease concepts and consequences for research
  - Basics about incidence, prevalence etc., and orphan indications
  - How to choose the appropriate research type and methodology
  - Ethical considerations including ethics application
  - Pros and cons of different types of research
  - Coordination of complex approaches incl. timing and resources
  - How to measure success?
  - Outcome variables
  - Improving the translational process
  - Challenges of communication?
  - How independent is translational science?
  - Academic boundary conditions vs. industrial influences
  - Positive and negative examples will be illustrated by distinguished guest speakers.

Prerequisites / notice:
- Only for Health Sciences and Technology MSc.

Compulsory Courses:

<table>
<thead>
<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>376-0302-01L</td>
<td>GCP Basic Course (Modules 1 and 2)</td>
<td>O</td>
<td>1 credit</td>
<td>1G</td>
<td>G. Senti, C. Fila, R. Grossmann</td>
</tr>
</tbody>
</table>

Abstract:
- The basic course in “Good Clinical Practice” (GCP) contains two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.
Objective
Students will get familiar with:
- Key Ethics documents
- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Content
Module 1:
Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
</tr>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>J. Vårös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>
History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.
Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes
Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice
No specific requirements, BUT
ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while
HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field

Bioelectronics and Biosensors
W 6 credits 2V+2U J. Vörös, M. F. Yanik

227-0393-10L Autumn Semester 2022
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

227-0447-00L Image Analysis and Computer Vision W 6 credits 3V+1U E. Konukoglu, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

227-0939-00L Cell Biophysics W 6 credits 4G T. Zambelli

Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann’s law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o’clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Prerequisites


Participants need a good command of:

- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton’s and Coulomb’s laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Taught
capabilities

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

227-0965-00L Micro and Nano-Tomography of Biological Tissues W 4 credits 3G M. Stampanoni, F. Marone Welford

Abstract

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes

Available online
This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.
### Content

During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications.

This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

### Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

### Pricals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

### Literature


### Prerequisites / notice

- No mandatory prerequisites.
- Lecture notes will be distributed.
- Lecture notes will be recorded on the waiting list. All applicants must additionally register on this form: (link will follow)
- The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

### Abstract

The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

### Objective

- Understanding of
  1. the set-up and individual components of a TEM
  2. the basics of electron optics and image formation
  3. the basics of electron beam – sample interactions
  4. the contrast mechanism
  5. various sample preparation techniques

- Learning how to
  1. align and operate a TEM
  2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
  3. record electron diffraction patterns and index diffraction patterns
  4. interpret TEM data

### Content

### Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

### Pricals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

### Literature


### Prerequisites / notice

- No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

363-1163-00L Developing Digital Biomarkers Particularly suitable for students with a technical background who are interested in healthcare.

Abstract
The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Objective
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

Content
The course has four core learning objectives. Students should:
- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as "deep learning") have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature

Prerequisites / notice
Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

367-0021-00L Materials and Mechanics in Medicine W 4 credits 3G M. Zenobi-Wong, J. G. Snedeker

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
course website on Moodle

Literature
Introduction to Biomedical Engineering, 3rd Edition 2011.
Author: John Enderle, Joseph Bronzino, ISBN 9780123749796
Academic Press

376-0121-00L Multiscale Bone Biomechanics Number of participants limited to 30 W 6 credits 4S R. Müller, X.-H. Qin

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
course website on Moodle

Literature
Introduction to Biomedical Engineering, 3rd Edition 2011.
Author: John Enderle, Joseph Bronzino, ISBN 9780123749796
Academic Press

Number of participants limited to 30
Abstract

The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

Objective

The learning objectives include
1. advanced knowledge of the state-of-the-art in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Content

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy.

Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2×45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions Courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom format. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A).

Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

Lecture notes

Material will be provided on Moodle and eColab.

Prerequisites / notice

Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

376-0208-00L Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects

W 3 credits 2G O. Bar-Nur, K. De Bock

Abstract

The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimuli. In this course, the students will acquire insights into the molecular aspects of muscle biology and exercise, in addition to gaining hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

Objective

The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Content

The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

Topic 1: Molecular pathways that control muscle stem cell self-renewal and differentiation

Topic 2: Genome engineering to correct genetic mutations that cause muscle diseases

Topic 3: Muscle fiber composition, force production and insulin sensitivity

Topic 4: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group’s research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants the following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

i. Group 1: tissue culture, isolation of muscle stem cells via FACS, differentiation of muscle stem cell into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, Immunofluorescence.

ii. Group 2: tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers. Immunofluorescence in muscle stem cells and fibers.

iii. Group 3: ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, Immunofluorescence and western blot.

iv. Group 4: tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers. Western blot.

Prerequisites / notice

Prerequisites: 376-0006-02L Laboratory Course in Molecular biology

376-0816-00L Applied Human Research Project Management

W 4 credits 3G C. Lustenberger, M. Altermatt

Abstract

This course equips the students with several key principles such as good clinical practice, ethical study requirements, reproducible data management and effective oral, graphical, and written communication to design and manage good quality, ethically sound human research studies and represents a 101-toolkit of transferable research management skills/digital tools.
Objective
The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Create/select well-founded research hypothesis and study designs for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects
- Integrate principles of effective communication in speaking, writing and graphical illustrations of future research idea/output

Content
The course will cover the following topics:

- Introduction to different study designs and ethical requirements thereof in Switzerland
- Introduction to literature search and searching platforms
- How to collect and sort publications/keep up to date on research topic
- Inputs on critically evaluating papers
- How to pre-define study requirements to “future-proof” the research (hypothesis, sample size definition, pre-registration)
- Correct conduction of fundamental human research procedures (e.g., screening, consent process, CRF) and identification/prevention of deviations and emergencies (e.g., SAE/ACE, protocol violation, research misconduct)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metatiles)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

376-1103-00L  
**Frontiers in Nanotechnology**  
**W** 4 credits 4V  
V. Vogel, further lecturers

**Abstract**

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

**Objective**

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within mammade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

**Content**

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

**Lecture notes**

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

376-1151-00L  
**Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging**  
**W** 3 credits 2V  
C. Ewald

**Abstract**

Recently, several start-up companies are aiming to translate basic molecular findings into new drugs/therapeutic interventions to slow aging or post-pone age-related diseases (e.g., Google founded Calico or Craig Venter's Human Longevity, Inc.). This course will teach students the basic skill sets to formulate their own ideas, design experiments to test them and explains the next steps to translate the discoveries into products.

**Objective**

The objective of this course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention. Learning objectives include:

1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
2. Analyse/compare current molecular/genetic strategies that address these aging problems.
3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.

**Prerequisites / notice**

No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.

376-1176-00L  
**Wearable and Mobile Technologies of the Future - Focus on Sports and Health**  
**W** 4 credits 3G  
C. Menon, C. Ahmadizadeh, M. Elgend

**Number of participants limited to 60**

**Abstract**

This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

**Objective 1:**
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

**Objective 2:**
Acquire skills to design novel non-invasive technologies for sport and health.
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

376-1177-00L Human Factors I

**Abstract**
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people’s health, well-being, and satisfaction as well as the overall system performance.

**Objective**
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

**Content**
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

**Literature**
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

376-1179-00L Applications of Cybernetics in Ergonomics

**Abstract**
Cybernetics systems have been studied and applied in various research fields, such as for applications in ergonomics. Topics discussed in this lecture (man-machine-interaction, performance in multi-modal interactions, quantification in gestalt principles for the use in product development, information processing) are deepened with exercises conducted at our labs.

**Objective**
- Fitt's law applied in manipulation tasks
- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection
- Accommodation/vergence crosslink function
- Cross-link models in neurobiology- the ocular motor control system
- Human performance in optimization of production lines

**Literature**

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

**Abstract**
Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

**Objective**
- Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
- Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature
Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice
Target Group:
Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
Students of other departments, faculties, courses are also welcome.
The lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Biomedical Applications

Abstract

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

Content

Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the electronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photons, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

376-1353-00L Nanostructured Materials Safety  W  2 credits  1V  P. Wick

Abstract

Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

Objective

Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

Lecture notes

Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Prerequisites / notice

course “Introduction to Toxicology”

376-1504-00L Physical Human Robot Interaction (pHRI)  ■  W  4 credits  2V+2U  O. Lambercy

Abstract

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

Objective

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de-sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) Identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) Compare and select mechatronic components that optimally fulfill the defined design requirements;
3) Derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) Design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) Characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) Investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes

Will be distributed on Moodle before the lectures.
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life. The students are expected to have basic control knowledge from previous classes. http://www.relab.ethz.ch/education/courses/phri.html

Objective
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine. Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

376-1650-00L Clinical and Movement Biomechanics
Number of participants limited to 50.
W 4 credits 3G N. Singh, R. List, P. Schütz

Abstract
Measurement and modeling of the human movement during daily activities and in a clinical environment.
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

Content
This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling with regards to human movement.

376-1651-00L Ethics of Life Sciences and Biotechnology
Number of participants limited to 100.
W 3 credits 2V A. Blasimme, E. Vayena

Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

A. Identify ethical issues in in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

**Biocompatible Materials**

**Abstract**

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**

- Introduction to molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
- Principles of biocompatibility.
- Introduction into methodology used in biomaterials research and application.

**Prerequisites / notice**

Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.

**Big Data Analysis in Biomedical Research**

**Abstract**

Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data

**Objective**

This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and approaches. By the end of the course, students will conduct an independent data analysis project based on a biomedical problem of their choosing and using publicly available population-based biomedical datasets.

**Prerequisites / notice**

Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.

**Trauma Biomechanics**

**Abstract**

Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

**Objective**

Introduction to the basic principles of trauma biomechanics.

**Prerequisites / notice**

Introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

**Handouts**

- Big Data Analysis in Biomedical Research, M. Ristow, M. Zenobi-Wong
- Trauma Biomechanics - An Introduction to Injury Biomechanics, Springer Publ.
**Abstract**

Current topics in biomechanics presented by speakers from academia and industry.

**Objective**

Getting insight into actual areas and problems of biomechanics.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Conceptual Theories</th>
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<td>Techniques and Technologies</td>
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**Colloquium in Biomechanics**  

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<th>376-1974-00L</th>
<th>Colloquium in Biomechanics</th>
<th>W</th>
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**Abstract**

This course covers the main methods used in Biostatistics. It starts by revising Linear Models (Regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

**Objective**

After this course students:
- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

**Content**

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both: part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

**Prerequisites / notice**

The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommend to view the online R course "etutoR".

**Applied Biostatistics**  

<table>
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<tr>
<th>401-0629-00L</th>
<th>Applied Biostatistics</th>
<th>W</th>
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<tr>
<td></td>
<td>M. Tanadini</td>
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**Physics in Medical Research: From Atoms to Cells**  

<table>
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<th>402-0674-00L</th>
<th>Physics in Medical Research: From Atoms to Cells</th>
<th>W</th>
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<td>B. K. R. Müller</td>
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**Abstract**

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

**Objective**

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein proliferation and metabolism and to determine the relation between cell morphology and function.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinetic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biopsies.
**529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics**

**Objective**
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

**Content**
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation.

**Taught competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

**Literature**
Information about relevant literature will be available in the lecture & in the lecture notes.

**Prerequisites / notice**
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)

**535-0423-00L Drug Delivery and Drug Targeting**

**Abstract**
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

**Objective**
The students dispose of an overview on current principles and systems for controlled delivery and targeting of drugs. This focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

**Content**
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

**Taught competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

**Prerequisites**
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)

**Literature**
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

**Further references**
Further references will be provided in the course.

**551-0317-00L Immunology I**

**Abstract**
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien".

**Literature**
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods and Techniques</th>
<th>Assessed</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td></td>
<td>Critical Thinking</td>
<td>Assessed</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-direction and Self-management</td>
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**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Lecture notes**
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**551-0319-00L Cellular Biochemistry (Part I)**

| W | 3 credits | 2V | U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp |

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Lecture notes**
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**636-0108-00L Biological Engineering and Biotechnology**

| W | 4 credits | 3V | M. Fussenegger |

**Abstract**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**

**Lecture notes**
Handout during the course.

**752-3105-00L Physiology Guided Food Structure and Process Design**

| W | 3 credits | 2V | E. J. Windhab, M. Devezzeaux de Lavergne, B. von der Weid, T. Wooster |
Abstract

A ‘cook-and-look’ approach to process design is no longer applicable in the current environmental, nutritional and competitive constraints. The modern R&D chemical/food engineer should have a clear focus on the desired structure that needs to be achieved to design a process line or a processing equipment, coupled with in-depth knowledge of the processed materials.

Objective

The objective of this course is to highlight the intimate links between human physiology and product sensory and nutritional functions. To optimize these functions, an understanding of the physiological functions that interact and encode the actions of those product structures must be well understood.

Therefore the objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures.

The students will be exposed to this interplay all along the GI tract, including taste, aroma and texture perception, swallowing mechanics and gastro intestinal digestion with an engineering or physical sciences angle.

Major in Molecular Health Sciences

Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>376-0300-00L</td>
<td>Translational Science for Health and Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfrum</td>
</tr>
</tbody>
</table>

Abstract

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

Objective

After completing this course, students will be able to understand:

Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)

Content

What is translational science and what is it not?
How to identify need?
- Disease concepts and consequences for research
- Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources
How to measure success?
- Outcome variables
- Improving the translational process
Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.

376-0302-01L | GCP Basic Course (Modules 1 and 2)                      | O    | 1 credit | 1G    | G. Senti, C. Fila, R. Grossmann |

Abstract

The basic course in "Good Clinical Practice" (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

Objective

Students will get familiar with:
- Key Ethics documents
- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Content

Module 1:
Research and Research Ethics, Guidelines, (Inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0939-00L</td>
<td>Cell Biophysics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>

Abstract

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

• Basics of theory of probability
• Boltzmann’s law
• Entropy maximization and Gibbs free energy minimization
• Ligand-receptor: two-state systems and the MWC model
• Random walks, diffusion, crowding
• Electrostatics for salty solutions
• Elasticity: fibers and membranes
• Molecular motors
• Action potential: Hodgkin-Huxley model
• Photosynthesis and vision
• Gene regulation
• Development: Turing patterns
• Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o’clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of differentiation and integration of a function with one or more variables (basics of Analysis), Newton’s and Coulomb’s laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Taught competencies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
<td>not assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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327-2125-00L Microscopy Training SEM I - Introduction to SEM

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP0.html).

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.
Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications.

This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam-specimen interaction, image formation, image contrast and imaging modes. 
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.

376-0121-00L Multiscale Bone Biomechanics ■ W 6 credits 4S R. Müller, X.-H. Qin

Number of participants limited to 30

Abstract
The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ.

Multiscale imaging and simulation allows linking different levels of length scale, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.
The learning objectives include:
1. advanced knowledge of the state-of-the-are in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Objectives

Objective

Content

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on QAility and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A).

Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

Material will be provided on Moodle and eColab.

Lecture notes

Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

Objective

Number of Participants limited to 16

Content

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lecture by the professors in addition to a journal club presentation by the students. The students will gain hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise. The course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

- Topic 1: Molecular pathways that control muscle stem cell self-renewal and differentiation
- Topic 2: Genome engineering to correct genetic mutations that cause muscle diseases
- Topic 3: Muscle fiber composition, force production and insulin sensitivity
- Topic 4: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lecture by the professors in addition to a journal club presentation by the students. The students will gain hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise. The course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Prerequisites / notice

Prerequisites:
Lab Course in Molecular Biology (376-0006-02L)

Prerequisites:
Lab Course in Molecular Biology (376-0006-02L)
Content
Timely and concise presentations of postgraduate students, post-docs, senior scientists, professors, as well as external guests from both
academics and industry will present topics of their interest related to translational medicine.

Prerequisites / notice
No compulsory prerequisites, but student should have basic knowledge about biomedical research.

376-1151-00L Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging W 3 credits 2V C. Ewald Number of participants limited to 30.
Abstract
Recently, several start-up companies are aiming to translate basic molecular findings into new drugs/therapeutic interventions to slow aging or post-pone age-related diseases (e.g., Google founded Calico or Craig Venter's Human Longevity, Inc.). This course will teach students the basic skill sets to formulate their own ideas, design experiments to test them and explains the next steps to translate such ideas.
Objective
The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention.
Learning objectives include:
1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
2. Analyse/compare current molecular/genetic strategies that address these aging problems.
3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.

Content
Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.

Prerequisites / notice
No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.

376-1353-00L Nanostructured Materials Safety W 2 credits 1V P. Wick
Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection
Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials
Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website
Prerequisites / notice
course “Introduction to Toxicology”

376-1622-00L Practical Methods in Tissue Engineering W 5 credits 4P M. Zenobi-Wong, S. J. Ferguson, S. Grad, S. Schulze-Finke
Number of participants limited to 12.
Abstract
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.
Objective
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.
Prerequisites / notice
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

376-1681-00L Ethics of Life Sciences and Biotechnology W 3 credits 2V A. Blasimme, E. Vayena
Number of participants limited to 100.
Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences
Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:
A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.
The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.
All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

376-1723-00L Big Data Analysis in Biomedical Research W 4 credits 2V+2U E. Araldi, M. Ristow
Number of participants limited to 20.
Abstract
Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data
This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and machine learning approaches. For the final assessment, students will conduct an independent data analysis project based on a biomedial problem of their choosing and using publicly available population-based biomedical datasets.

While learning the programming skills needed to manipulate and visualize the data, participants will learn the statistical and modeling approaches for big data analysis. The course will cover:

- Basis of Python programming and UNIX;
- High performance computing;
- Manipulation and cleaning of large datasets with Pandas;
- Visualization tools (Matplotlib, Seaborn);
- Machine learning and numerical libraries (SciPy, NumPy, Statsmodels, Scikit-Learn);
- Statistical analysis and modeling of big data, and applications to biomedical datasets (statistical learning, distributions, linear and logistic regressions, principal component analysis, clustering, classification, time series analysis, tree-based methods, predictive models).

This course provides a detailed understanding of modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation.

Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging.

Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.

Lecture notes will be made available online.

Exercises are an integral part of the lecture.

Prerequisites:

529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

This course provides a detailed understanding of - development of T and B cells - the dynamics of a immune response during acute and chronic infection - mechanisms of immunopathology - modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Obtain a detailed understanding of - the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses, - recognition of pathogenic microorganisms by the host cells and molecular events thereafter, - events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells. - optimization of B cell responses by intelligent design of new vaccines

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Immunology I and II recommended but not compulsory

Immunology III

- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological textbook knowledge has evolved.

Obtain a detailed understanding of - the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses, - recognition of pathogenic microorganisms by the host cells and molecular events thereafter, - events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.

- Optimization of B cell responses by intelligent design of new vaccines

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Immunology I and II recommended but not compulsory

529-0041-00L
Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics
W 6 credits 3G
R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano

529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)


**551-0309-00L Concepts in Modern Genetics**

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIC348 at UZH.

*Abstract*

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

*Objective*

This course focuses on the concepts of classical and modern genetics and genomics.

*Content*

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

*Lecture notes*

Scripts and additional material will be provided during the semester.

**551-0317-00L Immunology I**

*Abstract*

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

*Objective*

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

*Content*

- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

*Lecture notes*

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien".

*Literature*

- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

*Prerequisites / notice*

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

*Taught competencies*

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- Method-specific Competencies
  - Analytical Competencies: not assessed
  - Decision-making: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: assessed
  - Negotiation: not assessed

- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: assessed

**551-0512-00L Current Topics in Molecular and Cellular Neurobiology**

Does not take place this semester. Number of participants limited to 8.

*Abstract*

The course is a literature seminar or “journal club”. Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

*Objective*

The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

*Content*

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance. You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

*Lecture notes*

Presentations will be made available after the seminars.

*Prerequisites / notice*

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).
551-0571-00L From DNA to Diversity (University of Zurich) W 2 credits 2V A. Hajnal, D. Bopp

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIC336

Mind the enrolment deadlines at UZH: https://www.uzh.ch/crmss/en/studies/application/deadline.html

Abstract
The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analysed model organisms.

Objective
By the end of this module, each student should be able to
- recognize the universal principles underlying the development of different animal body plans,
- explain how the genes encoding the molecular toolkit have evolved to create animal diversity,
- relate changes in gene structure or function to evolutionary changes in animal development.

Key skills:
By the end of this module, each student should be able to
- present and discuss a relevant evolutionary topic in an oral presentation,
- select and integrate key concepts in animal evolution from primary literature
- participate in discussions on topics presented by others

551-1153-00L Systems Biology of Metabolism W 4 credits 2V U. Sauer, N. Zamboni, M. Zampieri

Number of participants limited to 15.

Abstract
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content
The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics.

For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes
Script and original publications will be supplied during the course.

Prerequisites / notice
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

551-1177-00L Immunology: From Milestones to Current Topics W 4 credits 2S B. Ludewig, N. Pikor, L. Tortola, J. Kiseliew, A. Oxenius, University lecturers

Number of participants limited to 20.

Abstract
Milestones in Immunology: on old concepts and modern experiments

Objective
The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Content
Milestones and current topics of innate immunity, antigen presentatino, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

Lecture notes
Original and review articles will be distributed by the respective lecturer.

Literature
Lekturerunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15588

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies not assessed

Social Competencies
Communication assessed
Self-presentation and Social Influence not assessed

Personal Competencies
Critical Thinking assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

551-1303-00L Cellular Biochemistry of Health and Disease W 4 credits 2S V. Korkhov, T. Ishikawa, M. Jagannathan, R. Kroschewski, G. Neurohr, M. Peter, A. E. Smith, B. Snijder, K. Weiss

Number of participants limited to 20.

Abstract
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

Objective
Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry.

Content
Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

Literature
The literature will be provided during the course

Prerequisites / notice
The course will be taught in English.

636-0017-00L Computational Biology W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Stadler

Autumn Semester 2022
Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics
Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylogeography, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Literature
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course ‘Introduction to Programming’, which takes place in Basel before the start of the semester.

636-0108-00L Biological Engineering and Biotechnology W 4 credits 3V M. Fussenegger

Abstract
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content

Lecture notes
Handout during the course.

636-0507-00L Synthetic Biology II W 8 credits 4A S. Panke, Y. Benenson, J. Stelling

Abstract
Does not take place this semester.

Students in the MSC Biotechnology (Programme Regulations 2017) may select Synthetic Biology II instead of the Research Project I.

Objective
The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.

Content
Presentations on advanced synthetic biology topics (e.g. genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence, (DNA synthesis external,) implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (www.igem.org).

Lecture notes
Handouts during course

Prerequisites / notice
The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc.

This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April.

Please note that the number of ECTS credits and the actual work load are disconnected.

701-1703-00L Evolutionary Medicine for Infectious Diseases W 3 credits 2G A. Hall

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

The focus is on primary literature, but for some parts the following text books provide good background information:

Schmid Hempel 2011 Evolutionary Parasitology
Stearns & Medizhivov 2016 Evolutionary Medicine

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-3105-00L</td>
<td>Physiology Guided Food Structure and Process Design</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>E. J. Windhab, M. Devezeaux de Lavergne, B. von der Weid, T. Wooster</td>
</tr>
<tr>
<td>752-4009-00L</td>
<td>Molecular Biology of Foodborne Pathogens</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Loessner, M. Schmelcher, M. Schuppler, E. Wetter Slack</td>
</tr>
<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. B. Zimmermann</td>
</tr>
<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
</tr>
<tr>
<td>376-0300-00L</td>
<td>Translational Science for Health and Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfram</td>
</tr>
</tbody>
</table>
Translational science is a cross-disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

After completing this course, students will be able to understand:

- Disease concepts and consequences for research
- Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources

How to measure success?

- Outcome variables
- Improving the translational process
- Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.

The course language is English.

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

Course material: Script, computer demonstrations, exercises and problem solutions.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Positive and negative examples will be illustrated by distinguished guest speakers.

Only for Health Sciences and Technology MSc.

- Key Ethics documents
- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:

- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Module 1:
Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

Elective Courses

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+1A</td>
<td>V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.</td>
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<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>E. Konukoglu, F. Yu</td>
</tr>
<tr>
<td>Objective</td>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.</td>
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<tr>
<td>Content</td>
<td>This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.</td>
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<tr>
<td>Lecture notes</td>
<td>Course material Script, computer demonstrations, exercises and problem solutions</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.</td>
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</table>
Objective Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

227-1047-00L Consciousness: From Philosophy to Neuroscience
(University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI410

Abstract This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained. Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

Objective The course's goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought by modern cognitive neuroscience. We aim to clarify concepts, explain their philosophical and scientific backgrounds, and to present experimental protocols that shed light on a variety of consciousness related issues.

Content The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of consciousness, and proposals for the neural correlate of consciousness (NCC).

Literature None

Prerequisites / notice Since we are all experts on consciousness, we expect active participation and discussions!

327-2125-00L Microscopy Training SEM I - Introduction to SEM

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https:// scopem.ethz.ch/ education/MTP6.html).

All applicants must additionally register on this form: (link will follow)
The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopEM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective - Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes Lecture notes will be distributed.

Literature

Prerequisites / notice No mandatory prerequisites.
Introduction to TEM I

The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

**Content**
- Lecture notes will be distributed.
- The course is divided into lectures and practicals.
- **Lectures:**
  - Basics of electron optics and the TEM instrument set-up
  - TEM imaging modes and image contrast
  - STEM operation mode
  - Sample preparation techniques for hard and soft materials
- **Practicals:**
  - Demonstration of advanced Transmission Electron Microscopy techniques
  - Hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control.

**Prerequisites / notice**
- No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

**Literature**

**Practicals:**
- Demonstration of STEM operation mode
- Demonstration of advanced Transmission Electron Microscopy techniques
- Hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control.

**Literature**
- Methods and Concepts in Human Systems Neuroscience and Motor Control
- Applied Human Research Project Management
- Translation of Basic Research Findings from Genetics

**Prerequisites / notice**
- Number of participants limited to 30.
- Students are required to have successfully completed the course "Neural control of movement and motor learning" and to have basic knowledge of applied statistics.

**Abstract**
- The course provides hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (nerve/brain stimulation, EMG, EEG, psycho-physical paradigms etc.). Students read scientific material, set up experiments, perform measurements in the lab, analyse data, apply statistics and write short reports or essays.

**Objective**
- This course will prepare students for experimental work as it is typically done during the master thesis. The goal is to gain hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (for example peripheral nerve stimulation, electrical and magnetic brain stimulation, EMG, EEG, psycho-physical paradigms etc.). Students will learn how to perform small scientific projects in this area. Students will work individually or in small groups and solve scientific problems which require them to perform measurements in human participants, extract relevant readouts from the data, apply appropriate statistics and interpret the results. They will also be required to write small essays and reports and they will get feedback on their writing throughout the course.

**Number of participants limited to 30.**

**Prerequisites / notice**
- Number of participants limited to 30.
- Students are required to have successfully completed the course "Neural control of movement and motor learning" and to have basic knowledge of applied statistics.
and Molecular Mechanisms of Aging

Number of participants limited to 30.

Abstract
Recently, several start-up companies are aiming to translate basic molecular findings into new drugs/therapeutic interventions to slow aging or postpone age-related diseases (e.g., Google founded Calico or Craig Venter's Human Longevity, Inc.). This course will teach students the basic skill sets to formulate their own ideas, design experiments to test them and explains the next steps to translate.

Objective
The overall goal of this course is to develop current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention. Learning objectives include:
1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
2. Analyse/compare current molecular/genetic strategies that address these aging problems.
3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.

Content
Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.

Prerequisites / notice
No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.

376-1177-00L Human Factors I W 3 credits 2V M. Menozzi Jäckli, R. Huang, M. Siegrist

Abstract
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people’s health, well-being, and satisfaction as well as the overall system performance.

Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in design systems, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

376-1179-00L Applications of Cybernetics in Ergonomics W 1 credit 1U M. Menozzi Jäckli, Y. Huang, M. Siegrist

Abstract
Cybernetics systems have been studied and applied in various research fields, such as for applications in ergonomics. Topics discussed in this lecture (man-machine-interaction, performance in multi-modal interactions, quantification in gestalt principles for the use in product development, information processing) are deepened with exercises conducted at our labs.

Objective
To learn and practice cybernetics principles in interface designs and product development.

Content
- Fitt's law applied in manipulation tasks
- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection
- Accommodation/vergence crosslink function
- Cross-link models in neurobiology- the ocular motor control system
- Human performance in optimization of production lines

Literature

376-1305-00L Development of the Nervous System (University of Zurich) W 3 credits 2V University lecturers

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsss/en/studies/application/deadline s.html

Objective
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Content
- analyze structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system.
- identify key steps in development underlying neurological syndromes and diseases

Key skills
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

Literature
- The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
- BIO142 Developmental Biology, BIO143 Neurobiology

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1164 of 2345
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<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<td>Neural Systems for Sensory, Motor and Higher Brain Functions</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>J. Bohacek, R. Fiore, R. Polania, W. von der Behrens, J. Winterer, further lecturers</td>
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<td><em>Enrolment to this course unit only possible at ETH. No enrolment to</em></td>
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<td>Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html">here</a></td>
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<td>The course covers the structure, plasticity and regeneration of the</td>
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<td>adult nervous system (NS) with focus on: sensory systems, cognitive</td>
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<td>functions, learning and memory, molecular and cellular mechanisms,</td>
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<td>animal models, and diseases of the NS.</td>
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<td>The aim is to give a deepened insight into the structure, plasticity</td>
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<td>and regeneration of the nervous system based on molecular, cellular</td>
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<td>and biochemical approaches.</td>
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<td><strong>Content</strong></td>
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<td>The main focus is on the structure, plasticity and regeneration of</td>
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<td>the NS: biology of the adult nervous system; structural plasticity</td>
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<td>of the adult nervous system, regeneration and repair: networks and</td>
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<td>nerve fibers, regeneration, pathological loss of cells.</td>
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<td>The lecture requires reading of book chapters, handouts and original</td>
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<td>scientific papers. Further information will be given in the individual</td>
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<td>lectures and are mentioned on Moodle / OLAT.</td>
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<td>376-1414-00L</td>
<td>Current Topics in Brain Research (HS)</td>
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<td>1.5K</td>
<td>I. Mansuy, further lecturers</td>
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<td><strong>Abstract</strong></td>
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<td>Different national and international scientific guests are invited to</td>
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<td>present and discuss their actual scientific results.</td>
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<td>To exchange scientific knowledge and data and to promote communication</td>
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<td>and collaborations among researchers.</td>
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<td>For students: Critical discussion of current research. Students</td>
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<td>aiming at getting a credit point for this colloquium choose one topic</td>
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<td>and write a critical essay on the presented research topic.</td>
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<td><strong>Content</strong></td>
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<td>Different scientific guests working in the field of molecular</td>
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<td>cognition, neurochemistry, neuromorphology and neurophysiology</td>
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<td>present their latest scientific results.</td>
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<td><strong>Lecture notes</strong></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Some of the seminars will be shared with the Institute of Neuroinformatics (INI) of UZH.</td>
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<td>376-1504-00L</td>
<td>Physical Human Robot Interaction (pHRI)</td>
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<td>O. Lambercy</td>
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<td><strong>Abstract</strong></td>
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<td>This course focuses on the emerging, interdisciplinary field of</td>
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<td>physical human-robot interaction, bringing together themes from</td>
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<td>robotics, real-time control, human factors, haptics, virtual</td>
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<td>environments, interaction design and other fields to enable the</td>
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<td>development of human-oriented robotic systems.</td>
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<td><strong>Objective</strong></td>
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<td>The objective of this course is to give an introduction to the</td>
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<td>fundamentals of physical human robot interaction, through lectures</td>
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<td>on the underlying theoretical/mechatronics aspects and application</td>
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<td>fields, in combination with a hands-on lab tutorial. The course will</td>
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<td>guide students through the design and evaluation process of such</td>
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<td>systems.</td>
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<td>By the end of this course, you should understand the critical</td>
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<td>elements in human-robot interactions - both in terms of engineering</td>
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<td>and human factors - and use these to evaluate and de- sign a safe</td>
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<td>and efficient assistive and rehabilitative robotic systems.</td>
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<td>Specifically, you should be able to:</td>
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<td>1) identify critical factors in physical human-robot interaction and</td>
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<td>use these to derive design requirements;</td>
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<td>2) compare and select mechatronic components that optimally fulfill</td>
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<td>the defined design requirements;</td>
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<td>3) derive a model of the device dynamics to guide and optimize the</td>
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<td>selection and integration of selected components into a functional</td>
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<td>system;</td>
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<td>4) design control hardware and software and implement and test</td>
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<td>human-interactive control strategies on the physical setup;</td>
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<td>5) characterize and optimize such systems using both engineering and</td>
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<td>psychophysical evaluation metrics;</td>
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<td>6) investigate and optimize one aspect of the physical setup and</td>
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<td>convey and defend the gained insights in a technical presentation.</td>
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<td><strong>Content</strong></td>
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<td>This course provides an introduction to fundamental aspects of</td>
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<td>physical human-robot interaction. After an overview of human haptic,</td>
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<td>visual and auditory sensing, neurophysiology and psychophysics,</td>
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<td>principles of human-robot interaction systems (kinematics,</td>
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<td>mechanical transmissions, robot sensors and actuators used in these</td>
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<td>systems) will be introduced. Throughout the course, students will</td>
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<td>gain knowledge of interaction control strategies including</td>
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<td>impedance/admittance and force control, haptic rendering basics and</td>
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<td>issues in device design for humans such as transparency and</td>
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<td>stability analysis, safety hardware and procedures. The course is</td>
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<td>organized into lectures that aim to bring students up to speed with</td>
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<td>the basics of these systems, readings on classical and current topics</td>
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<td>in physical human-robot interaction, laboratory sessions and lab</td>
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<td>visits.</td>
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<td>Students will attend periodic laboratory sessions where they will</td>
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<td>implement the theoretical aspects learned during the lectures. Here</td>
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<td>the salient features of haptic device design will be identified and</td>
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<td>theoretical aspects will be implemented in a haptic system based on</td>
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<td>the haptic paddle (<a href="https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html">here</a>), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td>Will be distributed on Moodle before the lectures.</td>
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</table>
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

Objective

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinction different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Prerequisites / notice

The registration is limited to 26 students. There are 4 credit points for this lecture. The lecture will be held in English. The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html

Literature


376-1651-00L

Ethics of Life Sciences and Biotechnology

W 3 credits
2V
A. Blasimme, E. Vayena

Number of participants limited to 100

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester. The course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy. All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

376-1723-00L

Big Data Analysis in Biomedical Research

W 4 credits
2V+2U
E. Araldi, M. Ristow

Number of participants limited to 20.

Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data...
### Objective

This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and machine learning approaches. For the final assessment, students will conduct an independent data analysis project based on a biomedical problem of their choosing and using publicly available population-based biomedical datasets.

### Content

While learning the programming skills needed to manipulate and visualize the data, participants will learn the statistical and modeling approaches for big data analysis. The course will cover:

- Basis of Python programming and UNIX;
- High performance computing;
- Manipulation and cleaning of large datasets with Pandas;
- Visualization tools (Matplotlib, Seaborn);
- Machine learning and numerical libraries (SciPy, NumPy, Statsmodels, Scikit-Learn);
- Statistical analysis and modeling of big data, and applications to biomedical datasets (statistical learning, distributions, linear and logistic regressions, principal component analysis, clustering, classification, time series analysis, tree-based methods, predictive models).

### Prerequisites / notice

Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.

### Lecture notes

Scripts and additional material will be provided during the semester.

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#### 551-0309-00L

**Concepts in Modern Genetics**

*Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.*

*Please mind the ETH enrolment deadlines for UZH students: [https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html](https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html)*

**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics.

**Content**

The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**

Scripts and additional material will be provided during the semester.

**Literature**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020
- Other course materials will be provided during the course.

**Prerequisites / notice**

- For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students/special-students-university-of-zurich.html courses/special-degree-students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html
- Please mind the ETH enrolment deadlines for UZH students. Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.
- Information for UZH students:
  - Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.
  - Please mind the ETH enrolment deadlines for UZH students: [https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html](https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html)

**Taught competencies**

**Method-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Subject-specific Competencies**

- Techniques and Technologies
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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#### 551-0317-00L

**Immunology I**

*W 3 credits 2V M. Kopf, A. Oxenius*

**Abstract**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**

Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**

- Introduction and historical background
- Innate and adaptive immunity. Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien".

**Literature**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020
- Other course materials will be provided during the course.

**Prerequisites / notice**

- For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students/special-students-university-of-zurich.html courses/special-degree-students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html
- Please mind the ETH enrolment deadlines for UZH students. Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.
- Information for UZH students:
  - Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.
  - Please mind the ETH enrolment deadlines for UZH students: [https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html](https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html)

**Taught competencies**

**Method-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Subject-specific Competencies**

- Techniques and Technologies
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed
- Not assessed

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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#### 551-0319-00L

**Cellular Biochemistry (Part I)**

*W 3 credits 2V U. Kutay, G. Neurohr, M. Peter, K. Weis, I. Zemp*
The course introduces basic concepts of the interaction between nutrition and exercise performance.

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytokine signalling, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-translational regulation of gene expression.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**752-4009-00L Molecular Biology of Foodborne Pathogens**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2110-00L</td>
<td>Practical Training 12 Weeks (Job or Research Oriented)</td>
<td>W</td>
<td>15</td>
<td></td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school).</td>
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<tr>
<td>Objective</td>
<td>Students should exercise scientific working and/or get realistic insights into future jobs.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This version of internships lasts for at least 12 weeks full time equivalent.</td>
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**752-6403-00L Nutrition and Performance**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-2111-00L</td>
<td>Practical Training 8 Weeks (Job or Research Oriented)</td>
<td>W</td>
<td>10</td>
<td></td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school).</td>
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<tr>
<td>Objective</td>
<td>Students should exercise scientific working and/or get realistic insights into future jobs.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This version of internships lasts for at least 8 weeks full time equivalent.</td>
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</table>

**752-2112-00L Practical Training 4 Weeks (Job or Research Oriented)**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-2112-00L</td>
<td>Practical Training 4 Weeks (Job or Research Oriented)</td>
<td>W</td>
<td>5</td>
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<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school).</td>
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<tr>
<td>Objective</td>
<td>Students should exercise scientific working and/or get realistic insights into future jobs.</td>
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</table>
This version of internships lasts for at least 4 weeks full time equivalent.

### Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-HEST

see Science in Perspective: Language Courses ETH/UZH

### Research Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2100-00L</td>
<td>Research Internship</td>
<td>O</td>
<td>15</td>
<td></td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>12-week internship intended for exercising (independent) scientific working.</td>
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<tr>
<td>Objective</td>
<td>Students shall exercise scientific working as preparation for their master thesis.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The Research Internship lasts for at least 12 weeks full time equivalent. It can be combined with the Master Thesis.</td>
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</table>

### Master’s Thesis

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-2000-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30</td>
<td>71D</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>6-months research study with topics from the chosen major within the field of Health Sciences and Technology. In general, it includes the study of existing literature, the specification of the research question, the choice of the methodological approach, the collection, analysis and interpretation of data, and the written and oral reporting of the findings.</td>
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<tr>
<td>Objective</td>
<td>The students shall demonstrate their ability to carry out a structured, scientific piece of work independently.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The Master Thesis can only be started after the Bachelor Degree was obtained and/or master admission requirements have been fulfilled.</td>
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</table>

### Course Units for Additional Admission Requirements

The courses below are only for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>406-0253-AAL</td>
<td>Mathematics I &amp; II</td>
<td>E-</td>
<td>13</td>
<td>28R</td>
<td>A. Cannas da Silva, F. Da Lio</td>
</tr>
<tr>
<td>Abstract</td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td>Objective</td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td>Content</td>
<td>Mathematics I covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems, notably through linear algebra and calculus, with an emphasis on ordinary differential equations.</td>
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<td>The main focus of Mathematics II is multivariable calculus.</td>
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<td>The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.</td>
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<tr>
<td></td>
<td>Linear Algebra and Complex Numbers: systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvectors, eigenvalues and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.</td>
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<td>Ordinary Differential Equations: separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.</td>
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<td>Multivariable Differential Calculus: functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.</td>
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<td></td>
<td>Multiple integrals, line and surface integrals, work and flow, Green, Gauss and Stokes theorems, applications.</td>
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<tr>
<td></td>
<td>- Bretsch, O.: Linear Algebra with Applications (Pearson Prentice Hall).</td>
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<tr>
<td></td>
<td>- Thomas, G. B.: Thomas’ Calculus, Parts 2 (Pearson Addison-Wesley).</td>
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<tr>
<td>Prerequisites / notice</td>
<td>familiarity with the basic notions from Calculus, in particular those of function, derivative and integral.</td>
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<tr>
<td>Assistance</td>
<td>Tuesdays and Wednesdays 17-18h, in Room HG E 41.</td>
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</tbody>
</table>

| 376-0203-AAL    | Movement and Sport Biomechanics | E-   | 4    | 3R    | B. Taylor, N. Singh |
| Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. |
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course!

Abstract
Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

Objective
"Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics."

Content
Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

406-0062-AAL  Physics I
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective
The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts in mechanics.

Content
Book:

Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002, 544 S, ca.: Fr. 68.-

376-1714-AAL  Biocompatible Materials
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature
Literature:
  (available online via ETH library)

Handouts and references therein.
High-Energy Physics (Joint Master with IP Paris)

Core Subjects

Core Courses in Theoretical Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0843-00L</td>
<td>Quantum Field Theory I</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>R. Renner</td>
</tr>
</tbody>
</table>

Abstract

This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity.

Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

Objective

The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore, it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

Lecture notes

Will be provided as the course progresses

Taught competencies

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

Core Courses in Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>402-0891-00L</td>
<td>Phenomenology of Particle Physics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>P. Crivelli, A. de Cosa</td>
</tr>
</tbody>
</table>

Abstract

Topics to be covered in Phenomenology of Particle Physics I:
- Relativistic kinematics
- Decay rates and cross sections
- The Dirac equation
- From the S-matrix to the Feynman rules of QED
- Scattering processes in QED
- Experimental tests of QED
- Hadron spectroscopy
- Unitary symmetries and QCD
- QCD and alpha_s running
- QCD in e^+e^- annihilation
- Experimental tests of QCD in e^+e^- annihilation

Objective

Introduction to modern particle physics

Content

Topics to be covered in Phenomenology of Particle Physics I:
- Relativistic kinematics
- Decay rates and cross sections
- The Dirac equation
- From the S-matrix to the Feynman rules of QED
- Scattering processes in QED
- Experimental tests of QED
- Hadron spectroscopy
- Unitary symmetries and QCD
- QCD and alpha_s running
- QCD in e^+e^- annihilation
- Experimental tests of QCD in e^+e^- annihilation

Literature

As described in the entity: Lernmaterialien

Electives

Optional Subjects in Physics

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>402-0457-00L</td>
<td>Quantum Technologies for Searches of New Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Crivelli, D. Kienzler</td>
</tr>
</tbody>
</table>
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.

- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

### 402-0713-00L Astro-Particle Physics I

<table>
<thead>
<tr>
<th></th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>A. Biland</th>
</tr>
</thead>
</table>

**Abstract**
This lecture gives an overview of the present research in the field of Astro-Particle Physics, including the different experimental techniques.

In the first semester, main topics are the charged cosmic rays including the antimatter problem. The second semester focuses on the neutral components of the cosmic rays as well as on some aspects of Dark Matter.

**Objective**
Successful students know:
- experimental methods to measure cosmic ray particles over full energy range
- current knowledge about the composition of cosmic ray
- possible cosmic acceleration mechanisms
- correlation between astronomical object classes and cosmic accelerators
- information about our galaxy and cosmology gained from observations of cosmic ray

**Content**
First semester (Astro-Particle Physics I):
- definition of 'Astro-Particle Physics' 
- important historical experiments
- chemical composition of the cosmic rays
- direct observations of cosmic rays
- indirect observations of cosmic rays
- 'extended air showers' and 'cosmic muons'
- knee' and 'ankle' in the energy spectrum
- the 'anti-matter problem' and the Big Bang
- 'cosmic accelerators'

**Literature**
See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/

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### 402-0715-00L Low Energy Particle Physics

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<tr>
<th></th>
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<th>6 credits</th>
<th>2V+1U</th>
<th>A. S. Antognini, P. A. Schmidt-Wellenburg</th>
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</table>

**Abstract**
Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrons, muons and exotic atoms.

**Objective**
You will be able to present and discuss:
- the principle of the experiments
- the underlying technique and methods
- the impact and the context of these experiments on particle physics

**Content**
Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics", making use of high precision and high intensities.

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrons and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:

- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spin manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling....

**Literature**
Golub, Richardson & Lamoreaux: "Ultra-Cold Neutrons"
Rauch & Werner: "Neutron Interferometry"
Carlile & Willis: "Experimental Neutron Scattering"
Byrne: "Neutrons. Nuclei and Matter"
Klapdor-Kleingrothaus: "Non Accelerator Particle Physics"

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### 402-0725-00L Experimental Methods and Instruments of Particle

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<th>3V+1U</th>
<th>U. Langenegger, T. Schietinger</th>
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</table>

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Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrons, muons and exotic atoms.

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You will be able to present and discuss:
- the principle of the experiments
- the underlying technique and methods
- the impact and the context of these experiments on particle physics

**Content**
Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics", making use of high precision and high intensities.

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- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling....

**Literature**
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Carlile & Willis: "Experimental Neutron Scattering"
Byrne: "Neutrons. Nuclei and Matter"
Klapdor-Kleingrothaus: "Non Accelerator Particle Physics"

**Prerequisites / notice**
Einführung in die Kern- und Teilchenphysik / Introduction to Nuclear- and Particle-Physics
You understand the building blocks of particle accelerators. Modern analysis tools allows you to model state-of-the-art particle accelerators.

Concepts and Theories

Slides are handed out regularly, see http://www.physik.uzh.ch/en/teaching/PHY461/

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the introduction to the physics of neutrinos with special consideration of phenomena connected with neutrino masses. The course covers some basic underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.

402-0777-00L Particle Accelerator Physics and Modeling I

Abstract

This is the first of two courses, introducing particle accelerators from a theoretical point of view and covers state-of-the-art modelling techniques.

Objective

You understand the building blocks of particle accelerators. Modern analysis tools allows you to model state-of-the-art particle accelerators. In some of the exercises you will be confronted with next generation machines. We will develop a Python (or Julia) simulation tool that reflects the theory from the lecture.

Content

Here is the rough plan of the topics, however the actual pace may vary relative to this plan.

- Recap of Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

Lecture notes

Lecture notes

Prerequisites / notice

Physics, Computational Science (RW) at BSc. Level

This lecture is also suited for PhD. students

402-0830-00L General Relativity

Abstract

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as some of the phenomena it predicts (with a focus on black holes).

Objective

Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).

Content

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

Literature

C. Misner, K. Thorne and J. Wheeler: Gravitation
S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
D. O. Caldwell, Current Aspects of Neutrino Physics, Springer.
S. Weinberg - Gravitation and Cosmology
R. Wald - General Relativity
C. Misner, K. Thorne and J. Wheeler: Gravitation
S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
D. O. Caldwell, Current Aspects of Neutrino Physics, Springer.
S. Weinberg - Gravitation and Cosmology
R. Wald - General Relativity
S. Weinberg - Gravitation and Cosmology

402-0845-61L Effective Field Theories for Particle Physics

Abstract

The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. These topics will be discussed both in general terms and with specific phenomenological applications in the context of physics beyond the Standard Model, effective description of the weak interaction, as well as the description of non-perturbative strong interaction at low energies.
Objective

This course covers the basic concepts of effective field theories (EFTs) and dispersion theory. We will start by introducing the core concept of constructing EFTs and apply them to the low-energy description of the weak interaction and the effective description of heavy physics beyond the Standard Model.

In the next part of the course, we will discuss Chiral Perturbation Theory (ChPT), the low-energy effective theory of Quantum Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

Content

- Introduction to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

Prerequisites / notice

QFT-I (mandatory) and QFT-II (highly recommended)
Contents:
* Review of non-Abelian gauge theories and their quantization
* Spinor-helicity formalism
* Renormalization of QCD and running coupling constant
* Basic strong interaction processes
* Perturbation theory techniques: loops and phase space
* QCD perturbation theory and applications
* Proton structure in QCD
* Resummation of large logarithmic corrections
* Effective field theories
* Non-perturbative methods

Prerequisites / notice
The course assumes prior knowledge of the content of the quantum field theory 1+2 lectures.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Type</th>
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<td>402-0897-00L</td>
<td>Introduction to String Theory</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
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<tr>
<td>402-0899-65L</td>
<td>Higgs Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
</tr>
</tbody>
</table>

Abstract

Introduction to String Theory

Abstract
String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Objective
Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Content
- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- D-branes, T-duality
- supergravity as a low-energy effective theory, strings on curved backgrounds
- two-dimensional field theories (classical/quantum, conformal/non-conformal)

Literature
M.B. Green, J.H. Schwarz, E. Witten, Superstring Theory I, CUP (1987).

Prerequisites / notice
Recommended: Quantum Field Theory I (in parallel)

Higgs Physics

Abstract
This year we celebrate the tenth anniversary of the discovery of the Higgs boson. With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background and learn about the main experimental methods used to study the physics the Higgs boson.

Objective
With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background to understand the main production and decay channels of the Higgs boson at high-energy colliders, and the corresponding experimental signatures.

Content
Theory part:
- the Standard Model and the mass problem: WW scattering and the no-lose theorem
- the Higgs mechanism and its implementation in the Standard Model
- theoretical constraints on the Higgs mass; the hierarchy problem
- Higgs production in e+e- collisions
- Higgs production at hadron colliders
- Higgs decays to fermions and vector bosons
- Higgs differential distributions, rapidity distribution, pt spectrum and jet vetoes
- Higgs properties and beyond the Standard Model perspective
- Outlook: The Higgs sector in weakly coupled and strongly coupled new physics scenarios.

Experimental part:
Introductory material:
- basics of accelerators and detectors
- reminders of statistics: likelihoods, hypothesis testing
- reminders of multivariate techniques: Boosted Decision Trees and Neural Networks

Main topics:
- pre-history (pre-LEP)
- LEP1: measurements at the Z-pole
- Electroweak constraints
- LEP2: towards the limit mH<114 GeV
- TeVatron searches
- LHC:
  -- main channels overview
  -- dissect one analysis
  -- combine information from all channels
  -- differential measurements
  -- off-shell measurements
Literature

- Higgs Hunter's Guide
  (by S. Dawson, J. Gunion, H. Haber and G. Kane)
- "Combination of Tevatron searches for the standard model Higgs boson in the W+W- decay mode" HWW TeVatron combination - http://arxiv.org/abs/1001.4162
- "Evidence for a particle produced in association with weak bosons and decaying to a bottom-antibottom quark pair in Higgs boson searches at the TeVatron" http://arxiv.org/abs/1207.6436
- "Precise determination of the mass of the Higgs boson and tests of compatibility of its couplings with the standard model predictions using proton collisions at 7 and 8 TeV" https://arxiv.org/abs/1412.8662
- "Measurements of the Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data at √s=7 and 8 TeV" https://arxiv.org/abs/1606.02266
- "Projections of Higgs Boson measurements with 30/fb at 8 TeV and 300/fb at 14 TeV" https://twiki.cern.ch/twiki/bin/view/CMSPublic/HigProjectionEsq2012TWiki

Prerequisites / notice

Prerequisites: Quantum Field Theory I, Phenomenology of Particle Physics I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>401-3461-00L</td>
<td>Functional Analysis I</td>
<td>W</td>
<td>10</td>
<td>4V+1U</td>
<td>P. Hintz</td>
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</tbody>
</table>

Autumn Semester 2022

Data: 18.08.2022 12:39
Particle Physics at PSI (Paul Scherrer Institute)

Students learn all the different steps it takes to perform a complete particle physics experiment in a small team. They acquire skills to do this themselves in the team, including design, construction, data taking and data analysis.

The Standard Model of particle physics is a monumental achievement of human ingenuity. While typically approached from the theoretical side, in this proseminar we will collect the experimental evidence upon which the Standard Model has been built.

Prerequisites / notice
Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and L^p spaces).

Proseminars and Semester Papers

To organise a semester project take contact with one of the instructors.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>402-0717-MSL</td>
<td>Particle Physics at CERN 🌈</td>
<td>W</td>
<td>8</td>
<td>15P</td>
<td>W. Lustermann</td>
</tr>
<tr>
<td>Abstract</td>
<td>During the semester break participating students stay for 4 weeks at CERN and perform experimental work relevant to our particle physics projects. Dates to be agreed upon.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students learn, by doing, the needed skills to perform a small particle physics experiment: setup, problem solving, data taking, analysis, interpretation and presentation in a written report of publication quality.</td>
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<td>Content</td>
<td>Detailed information in: <a href="https://ethelchenpraktikum.web.cern.ch/">https://ethelchenpraktikum.web.cern.ch/</a></td>
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<td>Prerequisites / notice</td>
<td>Language of instruction: English or German</td>
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| 402-0719-MSL | Particle Physics at PSI (Paul Scherrer Institute) 🌈 | W    | 8    | 15P   | A. Soter, A. S. Antognini |
| Abstract | During semester breaks 6-12 students stay for 3 weeks at PSI and participate in a hands-on course on experimental particle physics. A small real experiment is performed in common, including apparatus design, construction, running and data analysis. The course includes some lectures, but the focus lies on the practical aspects of experimenting. |      |      |       |                     |
| Objective | Students learn all the different steps it takes to perform a complete particle physics experiment in a small team. They acquire skills to do this themselves in the team, including design, construction, data taking and data analysis. |      |      |       |                     |
| Prerequisites / notice | |      |      |       |                     |

| 402-0210-MSL | Proseminar Theoretical Physics 🌈 | W    | 8    | 4S    | Supervisors |
| Abstract | A guided self-study of original papers and of advanced textbooks in theoretical physics. Within the general topic, determined each semester, participants give a presentation on a particular subject and deliver a written report. |      |      |       |                     |

| 402-0217-MSL | Semester Project in Theoretical Physics 🌈 | W    | 8    | 15A   | Supervisors |
| Abstract | This course unit is an alternative if no suitable "Proseminar Theoretical Physics" is available if the proseminar is already overbooked. Die Leistungskontrolle erfolgt aufgrund eines oder mehrerer schriftlicher Berichte bzw. einer schriftlichen Arbeit. |      |      |       |                     |
| Prerequisites / notice | The number of participants is limited. |      |      |       |                     |

| 402-0740-00L | Experimental Foundations of Particle Physics 🌈 | W    | 8    | 3S    | M. Backhaus, M. Donegá |
| Abstract | The Standard Model of particle physics is a monumental achievement of human ingenuity. While typically approached from the theoretical side, in this proseminar we will collect the experimental evidence upon which the Standard Model has been built. The course is completed with in class detector demonstrations: - cloud chamber |      |      |       |                     |
| Objective | This course integrates knowledge of all detector components (tracking, calorimetry, trigger) in discussing the experiments as a whole. It is meant to be complementary to the "Experimental Methods" course 402-0725-00L which introduces different detector technologies. It also augments the particle physics master curriculum and is meant to be followed in parallel to PPP I (402-0891-00L) or PPP II (402-0702-00L). |      |      |       |                     |
| Content | The course will not follow the historical trajectory of experimental particle physics. It will instead try to give a modern view of the results of the experiments and show where they fit in the theoretical construction. |      |      |       |                     |
| Literature | Cahn, Goldhaber "Experimental Foundations of Particle Physics" (2nd edition), Cambridge University Press |      |      |       |                     |
| Recommendations | Bettini, "Introduction to Elementary Particle Physics" Cambridge University Press |      |      |       |                     |
| Prerequisites / notice | Recommended: Phenomenology of Particle Physics I (or II) (in parallel) |      |      |       |                     |
| Taught competencies | |      |      |       |                     |
| Subject-specific Competencies | Concepts and Theories | assessed | | |                     |
| Method-specific Competencies | Analytical Competencies | assessed | | |                     |
| Social Competencies | Communication | assessed | | |                     |
| Personal Competencies | Critical Thinking | assessed | | |                     |
| | Integrity and Work Ethics | assessed | | |                     |
| | Self-direction and Self-management | assessed | | |                     |

| 402-0215-MSL | Experimental Semester Project in Physics 🌈 | W    | 8    | 15A   | Supervisors |
| Abstract | The aim of the project is to give the student experience in working in a research environment, carrying out physics experiments, analysing and interpreting the resulting data. |      |      |       |                     |
| Prerequisites / notice | |      |      |       |                     |
Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-PHYS

see Science in Perspective: Language Courses ETH/UZH

Master’s Thesis

<table>
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<tr>
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<td>Master students who cannot document</td>
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<td>to have received an adequate training</td>
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High-Energy Physics (Joint Master with IP Paris) - Key for Type

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Key for Hours

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<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

[ ] Special students and auditors need special permission from the lecturers.
The students learn about the structure and function of the musculoskeletal system and important disorders on the basis of exemplary understanding of the basic concepts of chemistry. Understanding the importance of chemical processes in human physiology and in the diagnosis and treatment of human disease.

1) Students can explain the importance of evolution for the development of humans and diseases.

2) The students know the cell as the smallest unit of the body. They can explain how the functions of the cell are disturbed in certain diseases and where therapies intervene. They can describe the multiplication of cells in the body and show how errors in this multiplication can lead to diseases.

3) The students know DNA as the basis of life. They can explain how the DNA information is stored and how this information can be reproduced and protected from damage. They can describe how the information is read and translated into proteins. They can explain which mechanisms at the level of DNA, RNA and proteins can cause diseases.

4) Students can explain which technologies can be used to diagnose and treat diseases.

5) Students can explain how people differ genetically and know the molecular basis of these differences. They can explain how these differences can lead to diseases and why some of these differences do not affect diseases.

6) The students know the molecular causes of the most common hereditary diseases and can determine the probability of occurrence and transmission to offspring.

7) Students can explain the biochemical and molecular basis of human reproduction and know the basic principles of human embryonic development. The students can explain which mechanisms can be disturbed by a faulty development.

---

**Subject Areas of Nervous System**

1. Basics of neurophysiology, stimulus conduction and processing using the example of the motor end plate, peripheral nervous system, associated clinical pictures (myasthenia gravis).
2. Structure, circuits and pathways in the spinal cord, spinal nerves, motor stimulus conduction in the spinal cord, spinal cord lesions and pain.
3. Anatomy and function of the brain stem and cranial nerves and their significance for motor and sensory functions, lesions (brain stem syndromes).
4. Anatomy and function of basal ganglia, thalamus and hypothalamus, control of the autonomic nervous system (homeostasis, food and water intake), basal ganglia defects using Parkinson's disease as an example.
5. Anatomy and function of the cerebellum and vestibular system, fine control of motor functions, associative learning, cerebellar symptoms (ataxias), organ of equilibrium.
6. Anatomy and function of the cerebrum, sensory and motor processing, cognition, learning and memory, neurodegenerative (Alzheimer) and neuropsychiatric (schizophrenia) disorders.

---

**Subject Areas of Molecular Genetics and Cell Biology**

1. The course teaches the basic principles of evolution, cell biology, molecular biology, genetics and developmental biology using the example of humans.
2. The students know the cell as the smallest unit of the body. They can explain how the functions of the cell are disturbed in certain diseases and where therapies intervene. They can describe the multiplication of cells in the body and show how errors in this multiplication can lead to diseases.
3. The students know DNA as the basis of life. They can explain how the DNA information is stored and how this information can be reproduced and protected from damage. They can describe how the information is read and translated into proteins. They can explain which mechanisms at the level of DNA, RNA and proteins can cause diseases.
4. Students can explain which technologies can be used to diagnose and treat diseases.
5. Students can explain how people differ genetically and know the molecular basis of these differences. They can explain how these differences can lead to diseases and why some of these differences do not affect diseases.
6. The students know the molecular causes of the most common hereditary diseases and can determine the probability of occurrence and transmission to offspring.
7. Students can explain the biochemical and molecular basis of human reproduction and know the basic principles of human embryonic development. The students can explain which mechanisms can be disturbed by a faulty development.
Content

The lecture elaborates the fundamental concepts of chemistry. The organization of the lecture is guided by the two textbooks "Chemie für Mediziner" by Zeeck et al. and Schmuck et al., respectively, referred to below. Accordingly, the following major subject areas will be covered: Atomic structure, periodic table of the elements, types of chemical bonds, states of matter, heterogeneous equilibria, thermodynamics and kinetics of chemical reactions, salt solutions, acids and bases, oxidation and reduction, metal complexes, fundamentals of organic chemistry, important classes of organic compounds and their reactivities, stereochemistry, amino acids and peptides, carbohydrates, lipids, heterocycles, spectroscopy in chemistry and medicine.

Lecture notes

Scripts for individual subject areas will be provided electronically prior to the corresponding lectures.

Prerequisites / notice

There are no English translations of these textbooks.

First Year Examination Block 2

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<tr>
<th>Number</th>
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<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>L. Keller</td>
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Abstract

Introduction of mathematics as the universal language for scientific facts:

The lecture aims on one hand at learning and exercising the mathematical trade and in the other hand at applying the learnt concept to medical, biological, chemical and mechanical problems.

Objective

Simple and complex facts can be described and analysed using mathematical tools.

Content

Used concepts: the notion of a function, of the derivative and the integral, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series.

Literature

G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag

Further reading suggestions will be indicated during the lecture

First Additional Year Courses

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<th>ECTS</th>
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<th>Lecturers</th>
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</table>

Abstract

Fundamental principles of human medicine, Basic Life Support (BLS) and introduction to histology and microscopy.

Objective

After completion of the course, the students:

- have a basic understanding of elementary building blocks and processes as a basis for human medicine, e.g. cell structure and cycle.
- know basic terminology of anatomy.
- understand the process of medical care from first aid to rehabilitation.
- understand the advantages and disadvantages of emergency diagnostics, especially ultrasound.
- know the basics of microscopy and histology.
- have learned the basics of Basic Life Support;
- recognize the symptoms of cardiovascular arrest.
- alarm in an emergency according to the situation.
- if available, they organize an AED and use it correctly and as quickly as possible.
- perform sufficient chest compressions on the phantom.
- perform effective ventilation on the phantom using a pocket mask.
- will identify possible ventilation complications. Under certain circumstances, they will not attempt further ventilation.
- will identify the limits of cardiopulmonary resuscitation.
- under stress, they do not risk their own or other "helpers" lives.

Content

Based on a complex clinical case, students are familiarized with the course of medical care from initial treatment to rehabilitation. Basic terms, modules and processes are introduced. In addition, the students experience the basics of imaging techniques, especially ultrasound. The students complete the Basic Life Support course. After this training sequence, all participants should be able to initiate resuscitation measures in private and in-hospital settings.

The students experience learning, teaching and working in the hospital sector as a social process and teamwork in which all senses and a wide range of skills are needed.

In addition, the students experience in three workshops the basic process of a physiotherapeutic intervention with the concepts of clinical reasoning, therapeutic aspects and therapy progression.

An intensive course in microscopy/histology enables students to perform microscopy independently and to understand histological sections of a histological sample, but also online.

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<td>Medical Interviewing Technique</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>S. Markun, S. Neuner-Jehle,</td>
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Abstract
The students know:
- the components of a strucured medical interview

The students can:
- perform a strucured medical interview
- initiate an adequate relation to patients

Content
Mixed teaching methods, including lectures and training in groups with real patients and simulated patients.

 Bachelor Studies (Programme Regulations 2018)
 Courses in Organ Systems and Clinical Practice
 Examination Block A

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<tr>
<th>Number</th>
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<td>Nutrition and Digestion</td>
<td>O</td>
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<td>W. Langhans, L. Käser, C. Stockmann</td>
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<tr>
<td>377-0301-03L</td>
<td>Endocrinology, Metabolism</td>
<td>O</td>
<td>5 credits</td>
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<td>M. Stoffel, F. Beuschlein, A. Hall, C. Wolffrn</td>
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Prerequisites / notice
The Immune system part of this course builds on the content of the "Infection and Immunology" course.

Prerequisites / notice
Voraussetzungen:
- LE 377-0105-00L Bewegungssapparat
- LE 377-0107-00L Nervensystem
- LE 377-0201-00L Herz-Kreislauf-System
- LE 377-0203-00L Atmungs-System
- LE 377-0205-00L Nieren und Hombostase

Suggested reference books include:
- Hoffbrand's Essential Haematology
- W. B. Saunders Co., 2016;
- http://www.library.ethz.ch/DADS:default_scope:ebi01_prod010873047
- https://institut.elsevierelibrary.de/product/basic-immunology85281

Prerequisites / notice
The course is supported by a Moodle page through which students have access to all necessary documentation.

Abstract
This course will focus on the components and functions of the hematopoietic and the immune systems and on diseases affecting or caused by these systems.

1. The organization and development of hematopoiesis including hematopoietic stem cell development; the role of hematopoietic growth and transcription factors in hematopoiesis; the role of hemoglobin in health and disease; erythrocyte physiology and iron metabolism; the principles of blood groups and blood transfusions; the principles of coagulation and the pharmacology of coagulation; the role of platelets and pharmacological platelet inhibition; to define thrombophilia and to understand thrombotic events; the role of leukocytes in health and disease; the analysis of blood samples; the principles of hematopoietic stem cell transplantation.

1. Introduction to hematopoiesis, hematopoietic growth factors, hematopoietic transcription factors, erythrocyte physiology, blood groups, blood transfusion, iron metabolism, platelets, coagulation cascade, fibrinolysis, hemoglobin, hemoglobinopathies, leukocytes (granulocytes, monocytes), clinical presentation of neutropenia, pharmacology of hemostasis, clinical presentation of thrombophilia, basics of hematopoietic stem cell transplantation, some aspects of laboratory medicine in hematology, virtual microscopy of blood and bone marrow smears.

2. Structure and anatomical position of primary and secondary lymphoid organs, cells and molecules of the innate immune system, T and B cell development and receptor diversity, major histocompatibility complex (MHC) and antigen presentation, effector B cells and antibodies, effector T cells, regulatory T cells and cytokines, allergy and hypersensitivities, autoimmunity and anti-inflammatory drugs, transplantation and immunosuppressive drugs, immunodeficiency, immune response in cancer and immunotherapies.

Abstract
The course focuses on the components and functions of the hematopoietic and the immune systems and on diseases affecting or caused by these systems.

1. The organization and development of hematopoiesis including hematopoietic stem cell development; the role of hematopoietic growth and transcription factors in hematopoiesis; the role of hemoglobin in health and disease; erythrocyte physiology and iron metabolism; the principles of blood groups and blood transfusions; the principles of coagulation and the pharmacology of coagulation; the role of platelets and pharmacological platelet inhibition; to define thrombophilia and to understand thrombotic events; the role of leukocytes in health and disease; the analysis of blood samples; the principles of hematopoietic stem cell transplantation.

2. Structure and anatomical position of primary and secondary lymphoid organs, cells and molecules of the innate immune system, T and B cell development and receptor diversity, major histocompatibility complex (MHC) and antigen presentation, effector B cells and antibodies, effector T cells, regulatory T cells and cytokines, allergy and hypersensitivities, autoimmunity and anti-inflammatory drugs, transplantation and immunosuppressive drugs, immunodeficiency, immune response in cancer and immunotherapies.

Objective
The aim of this module is that the students know and understand the morphology and function of the digestive system including its associated glands as well as the importance of nutrition for health. In particular, the students shall understand the relationships between food intake and digestion as well absorption and metabolism of particular nutrients. This knowledge shall enable the students to deduct the basic knowledge of therapies.

Objective
The aim of this module is that the students know and understand the morphology and function of the digestive system including its associated glands as well as the importance of nutrition for health. In particular, the students shall understand the relationships between food intake and digestion as well absorption and metabolism of particular nutrients. This knowledge shall enable the students to deduct the basic knowledge of therapies.
Upon successful completion of this module, students should:

- be able to explain the systematics of the endocrine system;
- know the structure and function of the hypothalamus, pituitary gland, adrenal gland, endocrine pancreas, thyroid gland, ovaries, testes;
- know the principles and regulation of bone, calcium and phosphate metabolism, energy balance, glucose metabolism, lipid metabolism, blood pressure;
- know the hormonally regulated metabolic processes (carbohydrates, protein and fat);
- know the most important endocrine diseases and tumors, their development, clinic, diagnostics and therapy;
- know the most important measures for the prevention of metabolic diseases and the underlying mechanisms.

In this module, students learn about anatomy, physiology, and pathophysiology of the endocrine glands, as well as the clinical, diagnostic, therapeutic, and preventive aspects of the most important endocrine diseases. This includes:

- Systematics of the endocrine system: structure and anatomical location of the various endocrine glands.
- Neuronal innervation and vascular supply area of the endocrine glands.
- Hormone classes: Protein and polypeptide hormones, amino and amino acid derivatives steroid hormones, biosynthesis of protein and polypeptide hormones, biosynthesis of amino and amino acid derivatives, biosynthesis of steroid hormones, storage of hormones, secretion of hormones, transport of hormones, half-lives, degradation and excretion of hormones.
- Transmission of information by hormones: hormone action at receptors, structure and function of membrane-associated hormone receptors, structure and function of nuclear receptors, regulation of hormone secretion.
- Structure and function of the hypothalamus, structure and function of the pituitary gland.
- Structure and function of the thyroid gland, under- and over-functioning of the thyroid gland, principles of diagnostics and therapy of thyroid diseases. Symptoms, medical history and clinical examination of thyroid diseases.
- Bones, calcium and phosphate metabolism.
- Regulation of glucose, lipid and protein metabolism, eating disorders, etiology, diagnostics, therapy and prevention of adipositas.
- Structure and function of the adrenal gland, pathogenesis, principles of diagnostics and therapy of diseases with hyper- and hypofunction of the adrenal gland. Symptoms, anamnesis and clinical examination in case of hyper- and hypofunction of the adrenal gland.
- Structure and function of the ovaries and testis, principles of reproductive physiology.

There is no traditional script for this course. Instead the course is supported by a Moodle page through which students have access to all necessary texts, exercises, videos and activities.

The essential course material will be available on the course's Moodle Page in the form of scripts and lesson handouts. The course does not have an "official" textbook, but students may find a general reference book on the topic interesting. For this purpose the text "Endokrinologie und Stoffwechsel" von Stefan Fischli and Giatgen A. Spinas (Herausgeber), Thieme Verlag, may be helpful.

The course builds on the content of the "Chemie für Mediziner", "Biochemie", "Pathobiocemie", "Pharmakologie für Mediziner" and "Molekulare Genetik und Zellbiologie" course and "Nutrition and Digestion".

### Examination Block B

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<td>0</td>
<td>4</td>
<td>3+1U</td>
<td>K. S. Kirch</td>
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This course is an introduction to classical physics, with special focus on applications in medicine.

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<tr>
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<td>LE 377-0205-00L</td>
<td>Nieren und Homöostase</td>
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### Additional Courses 2nd Year

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<td>377-0311-00L</td>
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<td>O</td>
<td>5</td>
<td>7P</td>
<td>J. Loffing, O. Ullrich, I. Amrein, G. Colaccio, N. Lier, further lecturers</td>
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Topographical Anatomy and Radioanatomy of the head, skull, central nervous system, neck and neck organs, upper and lower extremities, thoracic wall and organs, abdominal wall and organs, pelvis and pelvic organs, dorsal muscles, vessels, nerves, functions, clinical aspects. Methods: Anatomical dissection of human bodies.

### Additional Courses 3rd Year

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<td>O</td>
<td>1</td>
<td>1V</td>
<td>J. Goldhahn, R. W. Kressig, M. Martin, M. Ristow, further lecturers</td>
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Fundamentals and relevance of the aging process, as well as its biochemical, physiological and evolutionary basis. Insights into its individual as well as economic impact, including interventional and pharmacological treatment options.
Upon successful completion of the module, students should be able to
1. correctly describe the biological bases of the aging process;
2. derive physical and pharmacological choices to modulate the aging process;
3. understand the social and psychological implication of aging;
4. describe the specificities of geriatric medicine in the stationary setting;
5. identify the age-specific differences in both diagnostics and therapeutics.

Fundamentals and relevance of the aging process, as well as its biochemical, physiological and evolutionary basis. Insights into its individual as well as economic impact, including interventional and pharmacological treatment options.

Prerequisites:

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

Rheumatology

Disease patterns from the field of rheumatology. The main focus is on inflammatory diseases, including soft tissue and bone diseases.

Objective

At the end of the module, students should be able to do the following:
• list the typical symptoms and manifestations of the disease patterns;
• list the clinical examinations of the clinical pictures and explain the findings;
• list and justify further clarifications (such as laboratory tests, imaging, etc.) of the clinical pictures;
• recognize the respective clinical pictures of this topic block based on the symptoms, clinical examinations, findings and further clarifications;
• list the possible treatment options for the disease patterns and explain the indication, prevention and risk factors;
• Early detection of clinical pictures that require rapid therapy, identification of further steps for clarification and therapy;
• describe the causes and pathophysiological basis of the disease patterns.

Content

Overview Rheumatology, Rheumatoid Arthritis, M. Still, Spondyloarthritis, SAPHO Syndrome, Infectious and Crystal Arthritis, Juvenile Idiopathic Arthritis, CRPS, Soft Tissue Diseases, Myopathies, Bone Diseases, Vasculitis, Collagenosis, Drug Therapy in Rheumatology, Ergonomics, Occupational Reintegration.

Prerequisites:

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

Paediatrics

The module Paediatrics describes the peculiarities of the paediatric anamnese as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart and the most common respiratory diseases are described throughout the different age stages.

Objective

• Knowledge of the paediatric aspects of the medical history
• Knowledge of the enormous variety of child development (inter- and intra-individual variability)
• Milestone concept: Assessment of the stage of development of a child in the first years of life
• Landmark concept: first knowledge of the demilification on normality versus disorder
• Getting to know frequent developmental pediatric disorders
• Knowledge of the most common congenital heart defects
• Getting to know and recognize respiratory diseases of the upper and lower respiratory tract

Content

It describes the peculiarities of the pediatric anamnese as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart, and the most common respiratory diseases are described throughout the different age stages.

Prerequisites:

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

Emergency Medicine

By focusing on the 20 most frequent emergencies, the students will learn how to make quick decisions including diagnostic strategy and therapeutic measures. In practical exercises the students practice interprofessional aspects and discuss legal and ethical questions of emergency medicine.
Objective

Perform a triage based on the assessment of the vital signs.
Collect a targeted anamnesis (max. 5-6 questions) of a patient and/or family member
Determine the status of a patient with the necessary clinical examinations.
Determine a differential diagnosis based on the targeted anamnesis and the status.
Interpret the vital signs of a patient
Interpret the results of the paraclinical examinations and confirm/reject the differential diagnosis.
Based on the differential diagnosis, determine the necessary paraclinical examinations
Determine the next steps (treatment in hospital / by family doctor / immediate measures)
Identify possible therapeutic measures

Content

Mornings – case discussions & lectures entire group:
• Hypo / Hyperglycemia
• Principles of poisoning
• Acute Dyspnoea
• Cough
• Acute Diarrhoea
• Gastrointestinal bleeding
• Acute Kidney injury
• Hypertensive Crisis
• Acute Headache
• Coma
• Chest Pain
• Syncope
• Acute Abdominal pain
• Acute blood loss
• Common Trauma
• Head Trauma
• Fever in child
• Crying child
• Seizures and convulsions
• Dyspnoea in child

Afternoon – 4 smaller groups rotating:
• Emergency room (Hospital Lugano)
• Emergency call-center / Ambulance (Croce Verde - Lugano)
• Simulation center (Lugano)
• Case discussion (Bellinzona)
• BLS Refresh

Prerequisites / notice

Voraussetzungen:
LE 377-0101-00L Grundbausteine Mensch
LE 377-0211-00L Körperliche Untersuchung
LE 377-0411-00L Internistische Untersuchung
alle Organsysteme des 1.-4. Semesters

377-0509-00L Pathology

Only for Human Medicine BSc

O 6 credits 6G

V. Köhler, T. Cerny, S. Jeffery, J. Loffing, H. Moch, N. Rupp, J. Rüschoff, A. Sobottka-Brillout, further lecturers

Abstract

Pathology is the study of causes and effects of disease. This module pathology describes the pathogenetic processes and pathomorphological changes that occur in healthy and diseased tissues and cells of the human body. The module covers basic anatomical and surgical pathology and will cover the current and future possibilities of diagnostic practice in pathology.

Objective

After successfully completing the «General Pathology» module, students should be able to
1. to describe the goals and methods of pathoanatomical diagnostics and in reference to clinical practice,
2. to name the general causes and mechanisms of disease development and the associated pathomorphological changes in cells and tissues,
3. to fundamentally link the general causes and mechanisms of disease development with the therapeutic approaches that arise from them,
4. to describe the mechanisms of general inflammation, cell damage and circulatory pathology and relate them to the pathogenesis of specific diseases,
5. to explain the basics of the classification of benign and malignant tumors,
6. to describe the value of pathoanatomical and molecular diagnostics for the predictive and prognostic stratification of patients and to fundamentally relate them to clinical therapy decisions.

After successfully completing the «Surgical Pathology» module, students should be able to
1. to name the most important organ-specific diseases of the nervous system, the endocrine system, the cardiovascular system, the respiratory system, the digestive system, the urogenital system, the musculoskeletal system and the skin and to describe their characteristic macroscopic and microscopic manifestations,
2. to relate the etiology and pathogenesis of the most important organ-specific diseases to their morphological appearance and clinical presentation,
3. to describe the etiopathogenesis of the most important organ-specific diseases and to understand the relation to the mode of action of common therapeutic approaches,
4. to describe the fundamental importance of pathology and molecular diagnostics for personalized medicine and to describe specific application examples.
In the module "General Pathology" general causes and mechanisms of disease development and the associated pathomorphological changes in cells and tissues are discussed. Basics, current and future possibilities of pathoanatomical diagnostics are presented. The module "General Pathology" provides the basics for understanding the diseases treated in "Special Pathology".

The general pathology part covers the main topics:
1. revision and in-depth histology
2. introduction to pathology, histopathological and macroscopic tissue evaluation, postmortem diagnostics
3. introduction to causes and mechanisms of disease development
4. inflammation theory
5. cell damage and circulation pathology
6. general tumor theory
7. predictive pathology

In the module "Special Pathology" you will learn about the most important organ-specific diseases. Each half-day is built around a complex of topics related to special pathology, and is implemented using various teaching methods. The most important part is the main lecture, in which we systematically discuss the diseases of the organs and organ systems with you. Using macroscopic and microscopic slides, we will show you the relation to pathophysiology, symptomatology and medical diagnostics. We establish clinical references by broadcasting the mortality conference at the USZ. An integrated revision course and exercises based on PathoMaps offer you the opportunity to link the subject matter of the lecture with already known contents, to structure it further and to clarify open points together. Special lecture on molecular pathology, digital pathology and bioinformatics will introduce you to future technologies that are of particular importance for modern medicine.

The special pathology part covers the main topics:
1. upper and lower respiratory tract
2nd upper gastrointestinal tract
3. lower gastrointestinal tract
4. liver, gall bladder, pancreas
5. kidney, draining urinary tract
6. male sexual organs, prostate
7. female sexual organs, mamma
8. neurology

Prerequisites / notice
Voraussetzungen:
- LE 377-0105-00L Bewegungsapparat
- LE 377-0107-00L Nervensystem
- LE 377-0201-00L Herz-Kreislauf-System
- LE 377-0203-00L Atmungs-System
- LE 377-0205-00L Nieren und Harnstase
- LE 377-0301-01L Blut, Immunsystem
- LE 377-0301-02L Ernährung und Verdauung
- LE 377-0301-03L Endokrinologie, Stoffwechsel
- LE 377-0401-00L Sinnesorgane
- LE 377-0403-00L Haut und Anhangsorgane

377-0513-00L Ethics and Legal Aspects and Communication

Objective
After passing the modul sucessfully, students should be able to
- KNOW about ethical and legal basics of diagnostics and therapy and how these principles are put into practice
- KNOW knowledge and use of central communication skills with patients, health care teams and the public
- UNDERSTAND and describe the connections of ethics, law and communication and reflect on the implementation in clinical practice
- APPLY the concept of evidence based decision aids
- APPLY specific communication skills in simple clinical cases (informed consent, shared decision making, breaking bad news, communication of medical mistakes, Advance care Planning).
- UNDERSTAND the concept and needs of vulnerable patients and address the concept ethically, legally and communicate adequately
- KNOW about the necessity of interprofessional collaboration in the process of dealing with ethically and juridically complex cases and practice first steps.

Content
- OVERVIEW of clinical ethical cases
- BASICS in medical ethics and professional communication
- KNOWLEDGE and application of concepts as informed consent, possible alternative juridical instruments
- KNOWLEDGE and application of Shared decision Making
- KNOWLEDGE and application of advance care planning, concept of advance directives, treatment of patients incapable of decision making
- BREAKING bad news, difficult prognoses
- CONCEPT of vulnerability, special needs
- DIFFERENCES of research/clinic, concept of evidence-based and presonalized medicine
- CONFLICTS of interests in therapy and research
- BASICS on interprofessional cooperation in ethically and legally challenging situations
- GOAL of care approach, dealing with end of life decisions
- DIFFERENTIAL diagnoses and misdiagnosis, systems of avoidance of medical mistakes

Prerequisites / notice
Voraussetzungen:
- LE 377-0405-10L Bewegungsapparat
- LE 377-0403-00L Haut und Anhangsorgane
- LE 377-0301-01L Blut, Immunsystem

377-0515-00L Patient Journeys

Objective
- Students actively participate in interprofessional sessions, are open to other viewpoints, and consider these for the care and safety of the patients.
- Students deal with other health professionals and together plan an appropriate patient-path.
- The students are able to analyze an interprofessional patient-path and modify it according to the personal patient situation.
- Only for Human Medicine BSc

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1185 of 2345
Based on various patient situations, students learn how an interprofessional patient-path looks like. During the self-study time, the students bring “their own patient” from their private environment and accompany her/him during the patient-path. Within this framework, the individual path including all health professionals involved, will be analyzed. An exemplary patient case follows each session of the modules, to align the theoretical inputs with the corresponding patient case. In addition, together with pharmacy students, the students get to know the different roles of the pharmacy. In further sessions, the students learn which responsibilities, tasks and competences, various health professionals have, during the care of the patients on their path. In addition, the students have the opportunity to visit a rural hospital in another canton and become acquainted with the importance of the free choice of doctors and treatments in other Cantons.

377-0501-00L Reproduction

Only for Human Medicine BSc

Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislaufl-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0517-00L Oncology

Only for Human Medicine BSc

Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislaufl-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

Abstract
In this module, we lay the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and goes from the normal cycle of the woman and her disorders to the pregnancy and related issues to the obstetrics.

Objective
- **Anatomy**
  - Knowledge of the function of the female and male sexual organs
  - Explaining the development of the maternal and fetal parts of the placenta
  - Explaining the anatomy of the pelvis and the pelvic floor
- **Gynecology**
  - Recognizing gynecological emergencies
  - Listing of the various types of bleeding and irregularities
  - Overview of the benign tumors of the uterus and ovaries as well as the malignant tumors of the cervix and the endometrium
- **Reproductive Endocrinology**
  - Outlining of the main regulatory hormones of the female cycle and explaining their effects
  - Listing of the most important sterility factors
  - Discussing the main contraceptive methods with their mechanisms of action and contraceptive safety
- **Physiological situations in obstetrics**
  - Knowledge of the physiological processes and adaptation processes during pregnancy
  - Determination of birth process
  - Being aware of the meaning of the puerperium

Content
This module gives the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and shows the normal female cycle and her disorders as well as the pregnancy and related issues to the obstetrics. Students will have the opportunity to work with prospective midwives to learn basic skills of normal birth through a simulation.

Abstract
Advances in our knowledge of cancer genetic and the cancer immunology are changing the ways by which clinicians treat various types of cancer. This is a unique course designed to help students to learn about cutting-edge principles of cancer genetic, cancer immunology and target therapy and to apply these concepts to the clinical practice guided by leading experts in the field.

Objective
Students will learn basic concepts of cancer patients' management and will acquired knowledge regarding experimental and clinically approved anti-cancer therapies.
Content

Basic knowledge in oncology
1. The cancer outbreak and its prevention
2. Tumor diagnostic, imaging and screening
3. Basic principle of cancer management and tumor recurrence
4. Clinical application: a clinical case study

Experimental immuno-oncology
1. Hallmarks of Cancer
2. The promise of Immuno-oncology
3. Experimental Immunotherapies: Checkpoint Blockade and CAR T cells
4. From Bedside to Bench to Bedside (Journal Club)

Targeted therapy
1. Cancer Genomics and Epigenomics
2. Basic knowledge of signal transduction and cancer metabolism
3. From Arsenic Trioxide and Glivec to modern targeted therapies
4. Mechanism of resistance to targeted therapies

Oncology practice
1. Basic and clinical application: Chemotherapy
2. Basic and clinical application: Radiotherapy
3. Clinical application: Evidence Based Medicine in oncology
4. Design and analysis of Clinical Trial
5. Clinical application: Immunotherapy
6. Clinical application: Target Therapy
7. From Symptoms to diagnosis
8. Oncology Emergency

Prerequisites / notice

Prerequisites:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

<table>
<thead>
<tr>
<th>Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0683-00L</td>
<td>Statistics II</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
</tr>
</tbody>
</table>

Abstract

Extension of statistics for medical students. This lecture is based on the content of Statistics I. The focus will be on the understanding and the concrete application of statistical methods, as they are used in medical research. Exercises will be solved using the statistical programming environment R.

Objective

After this course you will understand the concept of a broad selection of statistical methods (see also Content). Furthermore, you will know when to use which method. Especially, you will be able to read, understand, and scrutinise the results from such methods, whether these results are written or graphical.

Using the statistical programming environment R, you will be able to read in data, analyse them in various ways, visualise and publish the results in reports or presentations. Knowing R will also enable you to reproduce published analyses, to check whether they work or to use them for your own medical research questions.
The course will cover the following topics. For the part on regression: simple linear regression; multiple regression (including factors and interactions); model selection; logistic regression (including odds ratio and their interpretation); Bayes inference. For the part on data: categorical data (including univariate tests); power analysis (including a guide on writing an ethics proposal); dealing with missing values. For the part on further methods: supervised vs unsupervised learning; dimensional reduction (including PCA and tSNE); survival analysis (including Kaplan-Meier curves and logrank test).

There is no script.

An Introduction to Statistical Learning with Applications in R
Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani
Springer, 2013; online available from the ETH Library

Required: Statistics I

Core Courses 3rd Year

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0866-00L</td>
<td>Foundations of Computer Science for Human Medicine Only for Human Medicine BSc</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>H.-J. Böckenhauer, D. Komm, M. Dahinden</td>
</tr>
<tr>
<td>377-0523-00L</td>
<td>Medical Technology I Only for Human Medicine BSc</td>
<td>O</td>
<td>3 credits</td>
<td>4G</td>
<td>R. Gassert, O. Lambercy</td>
</tr>
</tbody>
</table>

Core Courses 3rd Year

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W</td>
<td>4 credits</td>
<td>4V</td>
<td>V. Vogel, further lecturers</td>
</tr>
</tbody>
</table>

Compensatory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0021-00L</td>
<td>Materials and Mechanics in Medicine</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Zenobi-Wong, J. G. Snedeker</td>
</tr>
<tr>
<td>376-0864-00L</td>
<td>LE 402-0084-00L Physik II</td>
<td>O</td>
<td>3 credits</td>
<td>4G</td>
<td>R. Gassert, O. Lambercy</td>
</tr>
</tbody>
</table>
Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>4</td>
<td>W</td>
<td>K. Maniura, M. Rottmar, M. Zenobi-Wong</td>
</tr>
<tr>
<td>376-1561-00L</td>
<td>Clinical and Movement Biomechanics</td>
<td>4</td>
<td>G</td>
<td>N. Singh, R. List, P. Schütz</td>
</tr>
<tr>
<td>535-0022-00L</td>
<td>Computer-Assisted Drug Design</td>
<td>1</td>
<td>V</td>
<td>S. Riniker, G. Landrum</td>
</tr>
<tr>
<td>535-0250-00L</td>
<td>Biotransformation of Drugs and Xenobiotics</td>
<td>1</td>
<td>V</td>
<td>S.-D. Krämer</td>
</tr>
</tbody>
</table>

Abstract

Lecture notes

Handouts are deposited online (moodle).

Literature


Handouts and references therein.

Lecture notes

Script will be available.

Literature

- Recommended textbooks:

535-0250-00L Biotransformation of Drugs and Xenobiotics W 1 credits V S.-D. Krämer

Abstract

Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Objective

Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Content

Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics.

Lecture notes

Biotransformation of drugs and xenobiotics
# Glycobiology in Drug Development

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>535-0310-00L</td>
<td><strong>Glycobiology in Drug Development</strong></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.</td>
</tr>
</tbody>
</table>
| **Objective** | Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:  
- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.  
- the major types of protein-linked glycans and the biosynthetic pathways for their formation  
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).  

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper). Students gain the ability to reflect on roles of glycosylation in various biological contexts. |
| **Content** | lecture plan:  
1. Glycans - information carriers in biology and pharmacotherapy  
2. Glucocerebrosidase and the biosynthesis of N-glycans  
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering  
4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs  
5. Production and gCQA analysis of Glucocerebrosidase, monoclonal antibodies, glycoprotein hormone drugs - Glycoanalytics  
6. EPO "the same but different" |
| **Lecture notes** | The slides used for the lectures will be provided online |
- recent publications as cited/proposed on the lecture slides |
| **Prerequisites / notice** | Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology. |
| **Taught competencies** | Subject-specific Competencies  
Concepts and Theories | assessed |
Techniques and Technologies | assessed |
Method-specific Competencies  
Analysis Competencies | assessed |
Problem-solving | assessed |
Social Competencies  
Communication | assessed |
Personal Competencies  
Creative Thinking | assessed |
Critical Thinking | assessed |
| Further references will be provided in the course. |

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# Drug Delivery and Drug Targeting

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>535-0423-00L</td>
<td><strong>Drug Delivery and Drug Targeting</strong></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.</td>
</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.</td>
</tr>
</tbody>
</table>
Further references will be provided in the course. |
| **Taught competencies** | Subject-specific Competencies  
Concepts and Theories | assessed |
Techniques and Technologies | assessed |
Method-specific Competencies  
Analysis Competencies | assessed |
Problem-solving | assessed |
Social Competencies  
Communication | assessed |
Personal Competencies  
Creative Thinking | assessed |
Critical Thinking | assessed |

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# Molecular and Structural Biology I: Protein Structure and Function

D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course |
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td><strong>Molecular and Structural Biology I: Protein Structure and Function</strong></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.</td>
</tr>
</tbody>
</table>

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Lecture notes: Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature: 
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor(s)</th>
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<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>6</td>
<td>W</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
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<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
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<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
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<td>T. Städler, A. Widmer, S. Fior, M. C. Fischer, J. Stapley</td>
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<tr>
<td>752-4009-00L</td>
<td>Molecular Biology of Foodborne Pathogens</td>
<td>3</td>
<td>W</td>
<td>M. Loessner, M. Schmelcher, M. Schuppeler, E. Wetter Slack</td>
</tr>
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Data: 18.08.2022 12:39
Autumn Semester 2022
Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature

Recommendations will be given in the first lecture.

Prerequisites / notice

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

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752-5103-00L Functional Microorganisms in Foods

Abstract

This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective

To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefitting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content

This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.

- Legal and protection issues related to functional foods

- Industrial biotechnology of flavor and taste development

- Safety of food cultures and probiotics

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Lecture notes

Copy of the power point slides from lectures will be provided.

Literature

A list of topics for group projects will be supplied, with key references for each topic.

Prerequisites / notice

This lecture requires strong basics in microbiology.

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Human Medicine Bachelor - Key for Type

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<th>W+</th>
<th>W</th>
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<tr>
<th>E-</th>
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<tbody>
<tr>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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Key for Hours

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<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<th>D</th>
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<tbody>
<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Information Systems for Engineers

**Type:** Z  
**ECTS:** 4 credits  
**Hours:** 2V+1U  
**Lecturers:** G. Fourny

**Abstract**

This course provides the basics of relational databases from the perspective of the user. We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

**Objective**

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

**Content**

**Using a relational database**

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

**Taking a relational database to the next level**

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage
11. Analytics on top of a relational database

**Outlook**

12. Data cubes
13. Outlook

**Literature**

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

**Prerequisites / notice**

For non-CS/DS students only, BSc and MSc  
Elementary knowledge of set theory and logic  
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

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**Computer Science II**

**Type:** Z  
**ECTS:** 4 credits  
**Hours:** 2V+2U  
**Lecturers:** M. Schwerhoff, F. O. Friedrich Wicker

**Abstract**

The course provides the foundations for the design and analysis of algorithms. Classical problems ranging from sorting up to problems on graphs are used to discuss common data structures, algorithms and algorithm design paradigms. The course also comprises an introduction to parallel and concurrent programming.

**Objective**

An understanding of the analysis and design of fundamental and common algorithms and data structures. Knowledge regarding chances, problems and limits of parallel and concurrent programming.
Content

Data structures and algorithms: mathematical tools for the analysis of algorithms (asymptotic function growth, recurrence equations, recurrence trees), informal proofs of algorithm correctness (invariants and code transformation), design paradigms for the development of algorithms (induction, divide-and-conquer, backtracking and dynamic programming), classical algorithmic problems (searching, selection and sorting), data structures for different purposes (linked lists, hash tables, balanced search trees, heaps, union-find), further tools for runtime analysis (generating functions, amortized analysis). The relationship and tight coupling between algorithms and data structures is illustrated with graph algorithms (traversals, topological sort, closure, shortest paths, minimum spanning trees).

Parallel programming: structure of parallel architectures (multicore, vectorization, pipelining) concepts of parallel programming (Amdahl's and Gustavson's laws, task/data parallelism, scheduling), problem of concurrency (data races, bad interleaving, misunderstanding), process synchronisation and communication in a shared memory system (mutual exclusion, semaphores, monitors, condition variables). The concepts are underpinned with examples of concurrent and parallel programs and with parallel algorithms, implemented in C++.

In general, the concepts provided in the course are motivated and illustrated with practically relevant algorithms and applications.

Exercises are carried out in Code-Expert, an online IDE and exercise management system.

Lecture notes

All required mathematical tools above high school level are covered, including a introduction to graph theory.

Literature


Prerequisites / notice

Prerequisite: Computer Science I

252-0839-00L Informatics Z 2 credits 2G L. E. Fässler, M. Dahinden

Abstract

Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists and tables and with relational databases, introduction to programming.

Objective

The students learn to:
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

Content

1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python

Lecture notes

All materials for the lecture are available at www.evim.ethz.ch

Prerequisites / notice

This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

Taught competencies

Subject-specific Competencies
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication

Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

252-0845-00L Computer Science I Z 5 credits 2V+2U C. Cotrini Jimenez, M. Fischer

Abstract

The course covers the basic concepts of computer programming.

Objective

Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs. In the course "Computer Science I", the competency of programming is taught, applied and examined. Furthermore modelling is taught and applied.

Content

variables, types, control structures, functions, looping, recursion, object-oriented programming. The programming language is Python.

Lecture notes

The slides and lecture notes will be made available for download on the course website.

Literature

A Hands-On, Project-Based Introduction to Programming
Daniel Zingaro

Python Crash Course
Eric Matthes

Taught competencies

Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Creative Thinking

252-0847-00L Computer Science Z 5 credits 2V+2U C. Cotrini Jimenez, F. O. Friedrich Wicker

Abstract

The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Objective

Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.
The course covers fundamental data types, expressions and statements, (limit of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.

The students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects.

Techniques and Technologies
- handle the complexity of real-world data.

The main topics of the course unit "Computer Science in Secondary School Mathematics" represent a scientific and didactic added value.

The students learn to
- understand the role of computer science in science,
- to control computer and automate processes of problem solving by programming,
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

The following topics are covered: modeling and simulations, introduction to programming, introduction matrices, managing data with lists and tables and with relational databases, universal methods for algorithm design.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

The students develop an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

The general goal of the course consists in presenting ways to teach fundamentals of computer science, which are closely related to contents and methods of mathematics. After attending the course unit, a mathematics teacher is able to teach selected fundamentals of computer science in mathematics classes.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

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The students develop an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.
Didactics colloquium

Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

<table>
<thead>
<tr>
<th>Title</th>
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<th>Type</th>
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<td>6</td>
<td>2V+2U+1P</td>
<td>F. O. Friedrich Wicker, R. Sasse</td>
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<tr>
<td>252-0832-00L Computer Science I</td>
<td>Z</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Fischer, R. Sasse</td>
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</table>

### Abstract

- **252-0856-00L Computer Science**
  - The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.
  - **Objective**
    - Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.
  - **Content**
    - The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples.
  - **Lecture notes**
    - English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.
  - **Literature**
    - Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
    - Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000

- **252-0832-00L Computer Science I**
  - The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.
  - **Objective**
    - Primary educational objective is to learn programming with C++. When successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed.
    - Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.
  - **Content**
    - The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples.
    - In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.
  - **Lecture notes**
    - A script written in English will be provided during the semester. The script and slides will be made available for download on the course web page.
  - **Literature**
    - Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
    - Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000

### Generally Accessible Seminars and Colloquia

- **251-0100-00L Computer Science Colloquium**
  - Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.
  - **Objective**
    - Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department’s professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.
  - **Content**
    - Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

- **401-5960-00L Colloquium on Mathematics, Computer Science, and Education**
  - Subject didactics for mathematics and computer science teachers.
  - **Abstract**
    - Didactics colloquium

### Computer Science (General Courses) - Key for Type

<table>
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<th>Type</th>
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<tr>
<td>W</td>
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### Autumn Semester 2022

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### Key for Hours

<table>
<thead>
<tr>
<th>Hour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Many people can write programs. The "Introduction to Programming" course goes beyond that basic goal: it teaches the fundamental concepts and skills necessary to perform programming at a professional level. As a result of successfully completing the course, students will have mastered the fundamental control structures, data structures, reasoning patterns and programming language mechanisms characterizing modern programming, as well as the fundamental rules of producing high-quality software. They have the necessary programming background for later courses introducing programming skills in specialized application areas.

### Discrete Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0025-01L</td>
<td>Discrete Mathematics</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>U. Maurer</td>
</tr>
<tr>
<td>Objective</td>
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</tr>
<tr>
<td>Literature</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>Content: Mathematical reasoning and proofs, abstraction, Sets, relations (e.g. equivalence and order relations), functions, (un-)countability, number theory, algebra (groups, rings, fields, polynomials, subalgebras, morphisms), logic (propositional and predicate logic, proof calculi).</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The primary goals of this course are (1) to introduce the most important concepts of discrete mathematics, (2) to understand and appreciate the role of abstraction and mathematical proofs, and (3) to discuss a number of applications, e.g. in cryptography, coding theory, and algorithm theory.</td>
<td></td>
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<tr>
<td>Content</td>
<td>See course description.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Abgesehen vom Skript und Vorlesungsunterlagen empfehlen wir die folgenden Bücher als zusätzliches Nachschlagewerk.</td>
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</table>

### Algorithms and Data Structures

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0026-00L</td>
<td>Algorithms and Data Structures</td>
<td>O</td>
<td>7 credits</td>
<td>3V+2U+1A</td>
<td>M. Püschel, D. Steurer</td>
</tr>
<tr>
<td>Objective</td>
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</tr>
<tr>
<td>Literature</td>
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</tr>
<tr>
<td>Lecture notes</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The course provides the foundation of the design and analysis of algorithms. The material is introduced using classical algorithmic problems including graph problems. The necessary basic introduction to graph theory is provided as part of this course.</td>
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<tr>
<td>Objective</td>
<td>An understanding of the design and analysis of fundamental algorithms and data structures. A basic understanding of graph theory and several basic graph algorithms.</td>
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</tr>
<tr>
<td>Content</td>
<td>This course is an introduction into the design and analysis of algorithms. On the one hand this includes classical algorithm design patterns including induction, divide-and-conquer and dynamic programming. We study these using classical example such as searching and sorting. On the other hand the course covers the interaction between algorithms and data structures including linked lists, search trees, heaps, and union-find structures. A particular focus are graph algorithms for shortest path and minimal spanning tree problems. We provide the necessary introduction into graph theory as part of this course.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>A complete script in German is under development. A complete draft is already available on the course website.</td>
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</tbody>
</table>

### Introduction to Programming

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0027-00L</td>
<td>Introduction to Programming</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>T. Gross</td>
</tr>
<tr>
<td>Objective</td>
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<td></td>
</tr>
<tr>
<td>Literature</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>Introduction to fundamental concepts of modern programming and operational skills for developing high-quality programs, including large programs as in industry. The course introduces software engineering principles with an object-oriented approach based.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Many people can write programs. The &quot;Introduction to Programming&quot; course goes beyond that basic goal: it teaches the fundamental concepts and skills necessary to perform programming at a professional level. As a result of successfully completing the course, students master the fundamental control structures, data structures, reasoning patterns and programming language mechanisms characterizing modern programming, as well as the fundamental rules of producing high-quality software. They have the necessary programming background for later courses introducing programming skills in specialized application areas.</td>
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</tr>
<tr>
<td>Content</td>
<td>Basics of object-oriented programming. Objects and classes. Pre- and postconditions, class invariants, design by contract. Fundamental control structures. Assignment and references. Fundamental data structures and algorithms. Recursion. Inheritance and interfaces, basic concepts of Software Engineering such as the software process, specification and documentation, debugging, reuse and quality assurance.</td>
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</tr>
<tr>
<td>Literature</td>
<td>The lecture slides are available for download on the course page.</td>
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<tr>
<td>Lecture notes</td>
<td>See the course page for up-to-date information.</td>
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</table>

### Theoretical Computer Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0057-00L</td>
<td>Theoretical Computer Science</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>J. Hromkovic, H.-J. Böckenhauer, D. Komm</td>
</tr>
<tr>
<td>Abstract</td>
<td>Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be useful? d) What is nondeterminism and what role does it play in CS? e) How to represent infinite objects by finite automata and grammars?</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Learning the basic concepts of computer science along their historical development.</td>
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</tbody>
</table>
This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:
- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

The lecture is covered in detail by the textbook "Theoretical Computer Science".


Further reading:

This course does not cover how to design or build a processor or computer.

This course provides an overview of "computers" as a platform for the execution of (compiled) computer programs. This course provides a programmer's view of how computer systems execute programs, store information, and communicate. The course introduces the major computer architecture structures that have direct influence on the execution of programs (processors with registers, caches, other levels of the memory hierarchy, supervisor/kernel mode, and I/O structures) and covers implementation and representation issues only to the extent that they are necessary to understand the structure and operation of a computer system.

The course attempts to expose students to the practical issues that affect performance, portability, security, robustness, and extensibility. This course provides a foundation for subsequent courses on operating systems, networks, compilers and many other courses that require an understanding of the system-level issues. Topics covered include: machine-level code and its generation by optimizing compilers, address translation, input and output, trap/event handlers, performance evaluation and optimization (with a focus on the practical aspects of data collection and analysis).
Lecture notes
- C programming
- Integers
- Pointers and dynamic memory allocation
- Basic computer architecture
- Compiling C control flow and data structures
- Code vulnerabilities
- Implementing memory allocation
- Linking
- Floating point
- Optimizing compilers
- Architecture and optimization
- Caches
- Exceptions
- Virtual memory
- Multicore
- Devices

Literature
The course is based in part on "Computer Systems: A Programmer's Perspective" (3rd Edition) by R. Bryant and D. O'Hallaron, with additional material.

Prerequisites /
notice
252-0029-00L Parallel Programming
252-0028-00L Design of Digital Circuits

401-0213-15L Analysis II
<table>
<thead>
<tr>
<th>Analysis II</th>
<th>O</th>
<th>5 credits</th>
<th>2V+2U</th>
<th>Ö. Imamoglu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td></td>
<td>Differential and Integral calculus in many variables, vector analysis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td></td>
<td>Für allgemeine Informationen, sehen Sie bitte die Webseite der Vorlesung</td>
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</table>

401-0663-00L Numerical Methods for Computer Science
<table>
<thead>
<tr>
<th>Numerical Methods for Computer Science</th>
<th>O</th>
<th>7 credits</th>
<th>2V+2U+2P</th>
<th>R. Hiptmair</th>
</tr>
</thead>
<tbody>
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<td>Abstract</td>
<td></td>
<td>The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.</td>
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</table>

Abstract
Differential and Integral calculus in many variables, vector analysis.

Literature
Für allgemeine Informationen, sehen Sie bitte die Webseite der Vorlesung

Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently

Content
* Computing with Matrices and Vectors
  2.1 Fundamentals
  2.2 Software and Libraries
  2.4 Computational Effort
  2.5 Machine Arithmetic and Consequences
* Direct Methods for (Square) Linear Systems of Equations
  3.1 Introduction: Linear Systems of Equations (LSE)
  3.2 Theory: Linear Systems of Equations (LSE)
  3.5 Survey: Elimination Solvers for Linear Systems of Equations
  3.7 Sparse Linear Systems
* Direct Methods for Linear Least Squares Problems
  4.1 Least Squares Solution Concepts
  4.2 Normal Equation Methods
  4.3 Orthogonal Transformation Methods
  4.3.1 Transformation Idea
  4.3.2 Orthogonal/Unitary Matrices
  4.3.3 QR-Decomposition
  4.3.4 QR-Based Solver for Linear Least Squares Problems
  4.4 Singular Value Decomposition (SVD)
  4.5 SVD-Based Optimization and Approximation
* Filtering Algorithms
  5.1 Filters and Convolutions
  5.2 Discrete Fourier Transform (DFT)
  5.3 Fast Fourier Transform (FFT)
* Machine Learning of One-Dimensional Data (Data Interpolation and Data Fitting in 1D)
  6.1 Abstract Interpolation (AI)
  6.2 Global Polynomial Interpolation
  6.4 Splines
  6.7 Least Squares Data Fitting
* Iterative Methods for Non-Linear Systems of Equations
  9.2 Iterative Methods
  9.4 Finding Zeros of Scalar Functions
  9.5 Newton's Method in Rn
  9.7 Non-linear Least Squares

Lecture notes
Lecture materials (PDF documents and codes) will be made available to the participants through the course web page and online repositories. Access information will be communicated at the beginning of the course.
Hours
Lecturers
Compiler Design
ECTS
Computer Systems
4V+3U
This course uses compilers as example to expose modern software development techniques. The course introduces the students to
Analytical Competencies
8 credits
M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002
P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002
Prerequisites / notice
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object
oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves, in case they do
not know it already.
Taught competencies
Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
assessed
Method-specific Competencies
Analytical Competencies
assessed
Decision-making
not assessed
Problem-solving
assessed
Project Management
not assessed
Core Courses
Major: Information and Data Processing
Number
Title
Type
ECTS
Hours
Lecturers
252-0206-00L
Visual Computing
O
8 credits
4V+3U
M. Gross, M. Pollefeys
Abstract
This course acquaints students with core knowledge in computer graphics, image processing, multimedia and computer vision. Topics
include: Graphics pipeline, perception and camera models, transformation, shading, global illumination, texturing, sampling, filtering, image
representations, image and video compression, edge detection and optical flow.
Objective
This course provides an in-depth introduction to the core concepts of computer graphics, image processing, multimedia and computer
vision. The course forms a basis for the specialization track Visual Computing of the CS master program at ETH.
Content
Course topics will include: Graphics pipeline, perception and color models, camera models, transformations and projection, projections,
lighting, shading, global illumination, texturing, sampling theorem, Fourier transforms, image representations, convolution, linear filtering,
diffusion, nonlinear filtering, edge detection, optical flow, image and video compression.
Lecture notes
In theoretical and practical homework assignments students will learn to apply and implement the presented concepts and algorithms.
A scriptum will be handed out for a part of the course. Copies of the slides will be available for download. We will also provide a detailed list
of references and textbooks.
Literature
Major: Theoretical Computer Science
Number
Title
Type
ECTS
Hours
Lecturers
252-0209-00L
Algorithms, Probability, and Computing
O
8 credits
4V+2U+1A
B. Gärtner, R. Kynig. A. Steger, D. Steurer, E. Welzl
Abstract
Advanced design and analysis methods for algorithms and data structures: Random(ized) Search Trees, Point Location, Minimum Cut,
Linear Programming, Randomized Algebraic Algorithms (matchings), Probabilistically Checkable Proofs (introduction).
Objective
Studying and understanding of fundamental advanced concepts in algorithms, data structures and complexity theory.
Lecture notes
Will be handed out.
Literature
Introduction to Algorithms by T. H. Cormen, C. E. Leiserson, R. L. Rivest; Randomized Algorithms by R. Motwani und P. Raghavan;
Computational Geometry - Algorithms and Applications by M. de Berg, M. van Kreveld, M. Overmars, O. Schwarzkopf.
Major: Systems and Software Engineering
Number
Title
Type
ECTS
Hours
Lecturers
252-0210-00L
Compiler Design
O
8 credits
4V+3U
Z. Su
Abstract
This course uses compilers as examples to expose students to modern software development techniques. Tentative topics include:
compiler organization; lexical analysis; top-down and bottom-up parsing; symbol tables; semantic analysis; code generation; local and
global optimization; register allocation; automatic memory management.
Objective
Learn principles of compiler design; gain practical experience designing and implementing a medium-scale software system.
Content
This course uses compilers as example to expose modern software development techniques. The course introduces the students to the
fundamentals of compiler construction. Students will implement a simple yet complete compiler for an object-oriented programming
language for a realistic target machine. Students will learn the use of appropriate tools. Throughout the course, students learn to apply their
knowledge of theory (automata, grammars, stack machines, program transformation) and well-known programming techniques (module
definitions, design patterns, frameworks, software reuse) in a software project.
A tentative list of topics: compiler organization; lexical analysis; top-down and bottom-up parsing; symbol tables; semantic analysis; code
generation; local and global optimization; register allocation; automatic memory management; optional advanced topics if/when time
permits.
Literature
Prerequisites / notice
Prequisites:
Prior exposure to modern techniques for program construction, knowledge of at least one processor architecture at the assembly language
level.
252-0217-00L
Computer Systems
O
8 credits
4V+2U+1A
T. Roscoe, S. Shinde, R. Wattenhofer
Abstract
This course is about real computer systems, and the principles on which they are designed and built. We cover both modern OSes and the
large-scale distributed systems that power today’s online services. We illustrate the ideas with real-world examples, but emphasize
common theoretical results, practical tradeoffs, and design principles that apply across many different scales and technologies.
Objective

The objective of the course is for students to understand the theoretical principles, practical considerations, performance tradeoffs, and engineering techniques on which the software underpinning almost all modern computer systems is based, ranging from single embedded systems-on-chip in mobile phones to large-scale geo-replicated groups of datacenters.

By the end of the course, students should be able to reason about highly complex, real, operational software systems, applying concepts such as hierarchy, modularity, consistency, durability, availability, fault-tolerance, and replication.

Content

This course subsumes the topics of both "operating systems" and "distributed systems" into a single coherent picture (reflecting the reality that these disciplines are highly converged). The focus is system software: the foundations of modern computer systems from mobile phones to the large-scale geo-replicated data centers on which Internet companies like Amazon, Facebook, Google, and Microsoft are based.

We will cover a range of topics, such as: scheduling, network protocol stacks, multiplexing and demultiplexing, operating system structure, inter-process communication, memory management, file systems, naming, dataflow, data storage, persistence, and durability. computer systems performance, remove procedure call, consensus and agreement, fault tolerance, physical and logical clocks, virtualization, and blockchains.

The format of the course is a set of about 25 topics, each covered in a lecture. A script will be published online ahead of each lecture, and the latter will consist of an interactive elaboration of the material in the script. There is no book for the course, but we will refer to books and research papers throughout to provide additional background and explanation.

Prerequisites / notice

We will assume knowledge of the "Systems Programming" and "Computer Networks" courses (or equivalent), and their prerequisites, and build upon them.

Electives

Students may also choose courses from the Master's program in Computer Science. It is their responsibility to make sure that they meet the requirements and conditions for these courses.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0293-00L</td>
<td>Wireless Networking and Mobile Computing</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>S. Mangold</td>
</tr>
</tbody>
</table>

Abstract

This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.

Objective

The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.

Content

Wireless Communication, Wi-Fi, Contact Tracing, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.

Chapters:

1 Introduction
2 Wireless Communication Basics
3 IEEE 802.11 Wireless LAN (Wi-Fi)
4 IEEE 802.15 Wireless PAN (ZigBee & Bluetooth)
5 Mobile Computing Algorithm Basics: Control and Game Theory
6 Visible Light Communication
7 Audio Communication
8 Cellular Networking Basics (LTE, 5G, Internet-of-Things)
9 Mobile Computing for Automated Medicine Delivery
10 Cognitive Radio, Delay Tolerant Networking, Radio Spectrum Sharing

Lecture notes

The course material will be made available by the lecturer.

Literature

(1) The course webpage (look for Stefan Mangold's site)
(2) The Java 802 protocol emulator "JEmula802" from https://bitbucket.org/lfield/jemula802

Prerequisites / notice

Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
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...
### 252-3110-00L Human Computer Interaction

**Abstract**
The course provides an introduction to the field of human-computer interaction, emphasizing the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyze the user experience and show how these can inform the design of new interfaces, systems, and technologies.

**Objective**
The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context.

**Content**
The course will introduce students to several methods of analysing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing.

Students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

The course website can be found here: https://teaching.siplab.org/human_computer_interaction/2022/

### 151-0107-20L High Performance Computing for Science and Engineering (HPCSE) I

**Abstract**
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

**Content**
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

**Lecture notes**
https://www.cse-lab.ethz.ch/teaching/hpcs-e-i_hs22/

**Literature**
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vertex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

**Prerequisites / notice**
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

### 151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

**Abstract**
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

**Objective**
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.

The goal of the lecture is to provide a deeper knowledge of today’s VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

**Content**
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

**Lecture notes**
The handout is available in German and English.

**Prerequisites / notice**
"Visualization, Simulation and Interaction - Virtual Reality I" is recommended, but not mandatory.

**Didactical concept:**
The course consists of lectures and exercises.

**Taught competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Media and Digital Technologies
- Social Competencies: Communication
- Personal Competencies: Creative Thinking, Critical Thinking

### 227-0124-00L Embedded Systems

**Abstract**
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The goal of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

**Content**
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

**Lecture notes**
https://www.cse-lab.ethz.ch/teaching/hpcs-e-i_hs22/

**Literature**
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vertex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

**Prerequisites / notice**
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

**Didactical concept:**
The course consists of lectures and exercises.

**Taught competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Media and Digital Technologies
- Social Competencies: Communication
- Personal Competencies: Creative Thinking, Critical Thinking

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1203 of 2345
### Abstract
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

### Objective
Understanding specific requirements and problems arising in embedded system applications.

### Content
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C to base their design on the embedded operating systems FreeRTOS, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at [https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html](https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html).

The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at [https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html](https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html).

### Literature

### Prerequisites / notice
**Prerequisites:** Basic knowledge in computer architectures and programming.
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<th>Taught competencies</th>
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**Seminar**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-2300-00L</td>
<td>Neural Networks and Computational Complexity</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Cotterell</td>
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<td>Number of participants limited to 25.</td>
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<td>The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<td></td>
<td>Abstract</td>
<td>Dependency parsing is a fundamental task in natural language processing. This seminar explores a variety of algorithms for efficient dependency parsing and their derivation in a unified algebraic framework.</td>
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<td></td>
<td>Objective</td>
<td>The core ideas behind the mathematics of dependency parsing are explored.</td>
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<td>Content</td>
<td>Dependency Structures and Lexicalized Grammars: An Algebraic Approach</td>
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<tr>
<td>252-2600-05L</td>
<td>Software Engineering Seminar</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>Z. Su, M. Vechev</td>
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<td>Number of participants limited to 22.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>The course is an introduction to research in software engineering, based on reading and presenting high quality research papers in the field. The instructor may choose a variety of topics or one topic that is explored through several papers.</td>
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<td></td>
<td>Objective</td>
<td>The main goals of this seminar are 1) learning how to read and understand a recent research paper in computer science; and 2) learning how to present a technical topic in computer science to an audience of peers.</td>
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<td></td>
<td>Content</td>
<td>The technical content of this course falls into the general area of software engineering but will vary from semester to semester.</td>
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<tr>
<td>252-3400-00L</td>
<td>Seminar on Machine Learning Systems</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>A. Klimovic, C. Zhang</td>
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<td>Number of participants limited to 40.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>This seminar covers core concepts and ideas in the general area of machine learning systems, ranging from distributed and federated learning systems, DevOps systems for ML, life cycle and data management systems for ML, etc.</td>
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<td>Objective</td>
<td>The seminar covers core concepts and ideas in the general area of machine learning systems, ranging from distributed and federated learning systems, DevOps systems for ML, life cycle and data management systems for MLs, etc. The focus will be to cover fundamental ideas on ML systems, with an emphasis on software systems and platforms.</td>
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<td>Content</td>
<td>The seminar will consist of student presentations based on a list of papers that will be provided at the beginning of the course. Presentations will be done in teams. Presentations will be arranged in slots of 30 minutes talk plus 15 minutes questions. Grades will be assigned based on quality of the presentation, coverage of the topic including material not in the original papers, participation during the seminar, and ability to understand, present, and criticize the underlying technology.</td>
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<tr>
<td>252-3811-00L</td>
<td>Case Studies from Practice Seminar</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>M. Brandis</td>
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<td>Number of participants limited to 24.</td>
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<td></td>
<td>Abstract</td>
<td>Participants will learn how to analyze and solve IT problems in practice in a systematic way, present findings to decision bodies, and defend their conclusions.</td>
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<td>Objective</td>
<td>Participants understand the different viewpoints for IT-decisions in practice, including technical and business aspects, can effectively analyze IT questions from the different viewpoints and facilitate decision making.</td>
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</table>
Participants learn how to systematically approach an IT problem in practice. They work in groups of three to solve a case from a participating company in depth, studying provided materials, searching for additional information, analyzing all in depth, interviewing members from the company or discussing findings with them to obtain further insights, and presenting and defending their conclusion to company representatives, the lecturer, and all other participants of the seminar. Participants also learn how to challenge presentations from other teams, and obtain an overview of learnings from the cases other teams worked on.

Failing the seminar:

Students who are still enrolled at the end of the second week of the semester who do not attend the seminar will officially fail the seminar.

Lecture notes:

Methodologies to analyze the cases and create final presentations. Short overview of each case. Successful completion of Lecture “Case Studies from Practice”.

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<tbody>
<tr>
<td>101-0250-00L</td>
<td>Solving Partial Differential Equations in Parallel on</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>L. Räss, S. Omlin, M. Werder</td>
</tr>
</tbody>
</table>
**Abstract**
This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

**Objective**
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

**Content**
**Part 1 - Discovering a modern parallel computing ecosystem**
- Learn the basics of the Julia language;
- Learn about the diffusion process and how to solve it;
- Understand the practical challenges of parallel and distributed computing: (multi-)GPUs, multi-core CPUs;
- Learn about software development tools: git, version control, continuous integration (CI), unit tests.

**Part 2 - Developing your own parallel algorithms**
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Implement efficient iterative algorithms;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPPUs);
- Learn about main simulation performance limiters.

**Part 3 - Final project**
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

**Lecture notes**
Digital lecture notes, interactive Julia notebooks, online material.

**Literature**
Links to relevant literature will be provided during classes.

**Prerequisites / notice**
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

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**102-0227-00L Systems Analysis and Mathematical Modeling in Urban Water Management**

**Number of participants limited to 50.**

**Abstract**

**Objective**
The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

**Content**
The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

**Lecture notes**
Copies of overheads will be made available.

**Literature**
There will be a required textbook that students need to purchase:

**Prerequisites / notice**
Studends should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering la. It is beneficial but not necessary to follow both courses simultaneously.

**Taught competencies**

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**151-0573-00L System Modeling**

**W 4 credits 2V+1U**

**L. Guzzella**

**Abstract**
Introduction to system modeling for control. Generic modeling approaches based on first principles, Lagrangian formalism, energy approaches and experimental data. Model parametrization and parameter estimation. Basic analysis of linear and nonlinear systems.

**Objective**
Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.
This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.

The handouts in English will be available in digital form. A list of references is included in the handouts.

The handouts in English will be available in digital form. A list of references is included in the handouts.

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies

- Model scaling
- Linearization
- Order reduction
- Balancing
- Parameter estimation with least-squares methods

Social Competencies

- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract

Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

Objective

Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

Content

- Discrete-time signals and systems
- Fourier- and z-Transforms
- Frequency domain characterization of signals and systems
- System identification
- Time series analysis
- Filter design

Lecture notes

Lecture notes available on course website.

Prerequisites / notice

Control Systems I is helpful but not required.

151-0591-00L Control Systems I W 4 credits 2V+2U E. Frazzoli

Note: The previous course title in German until HS21 "Regelungstechnik I".

Abstract

Analysis and controller synthesis for linear time invariant systems with one input and one output signal (SISO); transition matrix; stability; controllability; observability; Laplace transform; transfer functions; transient and steady state responses. PID control; dynamic compensators; Nyquist theorem.

Objective

Identify the role and importance of control systems in everyday life. Obtain models of single-input single-output (SISO) linear time invariant (LTI) dynamical systems. Linearization of nonlinear models. Interpret stability, observability and controllability of linear systems. Describe and associate building blocks of linear systems in time and frequency domain with equations and graphical representations (Bode plot, Nyquist plot, root locus). Design feedback controllers to meet stability and performance requirements for SISO LTI systems. Explain differences between expected and actual control results. Notions of robustness and other nuisances such as discrete time implementation.

Content


Lecture notes

Lecture slides and additional material will be posted online.

There is no required textbook.

A nice introductory book on feedback control, available online for free, is:

Feedback Systems: An Introduction for Scientists and Engineers
Karl J. Astrom and Richard M. Murray

The book can be downloaded at https://fbswiki.org/wiki/index.php/Main_Page

Prerequisites / notice

Basic knowledge of (complex) analysis and linear algebra.
### Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
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### Theory of Robotics and Mechatronics

**Course Code**: 151-0601-00L
**Title**: Theory of Robotics and Mechatronics
**W**: 4 credits
**3G**: to be announced

**Abstract**
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**
Available.

### Stochastic Methods for Engineers and Natural Scientists

**Course Code**: 151-0709-00L
**Title**: Stochastic Methods for Engineers and Natural Scientists

**W**: 4 credits
**4G**: D. W. Meyer-Massetti

**Abstract**
The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent and subsurface flows. Moreover, mathematical techniques are presented that are used to quantify uncertainty in various engineering applications.

**Objective**
By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover, you should be able to develop basic stochastic models of such systems.

**Content**
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation

All topics are illustrated with engineering applications.

**Lecture notes**
Detailed lecture notes will be provided.

**Literature**
Some textbooks related to the material covered in the course:

### Sinusoidal Engineering II

**Course Code**: 227-0076-00L
**Title**: Sinusoidal Engineering II

**W**: 4 credits
**2V+2U**: C. Studer

**Abstract**
Sinusoidal signals and systems in the time and frequency domain, principle of operation and design of basic analog and digital circuits as well as analog-digital conversion.

**Objective**
see above

**Content**

### VLSI 1: HDL Based Design for FPGAs

**Course Code**: 227-0116-00L
**Title**: VLSI 1: HDL Based Design for FPGAs

**W**: 6 credits
**5G**: F. K. Gürkaynak, L. Benini

**Abstract**
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.
Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

Lecture notes
Handouts of the lecture

Literature

Prerequisites / notice
Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/

<table>
<thead>
<tr>
<th>227-0731-00L</th>
<th>Power Market I - Portfolio and Risk Management W</th>
<th>6 credits</th>
<th>4G</th>
<th>D. Reichelt, G. A. Koeppele</th>
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<tr>
<td>Lecture notes</td>
<td>Handouts of the lecture</td>
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<tr>
<td>Prerequisites / notice</td>
<td>1 excursion per semester, 2 case studies, guest speakers for specific topics.</td>
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<tr>
<th>227-0945-00L</th>
<th>Cell and Molecular Biology for Engineers I W</th>
<th>3 credits</th>
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<tr>
<td>Abstract</td>
<td>The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1210 of 2345
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

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**351-0778-01L Discovering Management (Exercises)**

*Complementary exercises for the module Discovering Management.*

**Prerequisite:** Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

**Abstract**

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

**Objective**

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

**Content**

Students who are enrolled for “Discovering Management Exercises” are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

Students have the option to either write this alone or in a group of two students.

**Literature**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

**363-0541-00L Systems Dynamics and Complexity**

*Finding solutions: what is complexity, problem solving cycle.*

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**363-1082-00L Enabling Entrepreneurship: From Science to Startup**

*Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they*
would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch

Abstract

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective

Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea

Content

The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders' agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Literature

Book
Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

Prerequisites / notice

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

Taught competencies

Method-specific Competencies

Media and Digital Technologies
Project Management

Social Competencies

Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility

Personal Competencies

Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

351-1109-00L Introduction to Microeconomics

GESS (Science in Perspective):

This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend “Principles of Microeconomics” (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed “Principles of Microeconomics” (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract

The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

This course “Einführung in die Mikroökonomie” (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 “Principles of Microeconomics” for Master students.

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Decision-making assessed

Media and Digital Technologies not assessed

Problem-solving not assessed

Project Management not assessed

Communication not assessed

Cooperation and Teamwork not assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence not assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Adaptability and Flexibility not assessed

Creative Thinking not assessed

Critical Thinking assessed

Integrity and Work Ethics not assessed

Self-awareness and Self-reflection not assessed

Self-direction and Self-management not assessed

Objective

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this promise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:

• understand the anatomy of digital biomarkers
• understand the potential and applications of digital biomarkers
• be able to critically reflect and assess existing digital biomarkers
• be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature

376-1177-00L  Human Factors I

W  3 credits  2V  M. Menozzi Jäckli, R. Huang, M. Siegrist

Abstract  Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.

Objective  The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content  - Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature  - Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

401-0353-00L  Analysis 3

W  4 credits  2V+2U  M. Iacobelli

Abstract  In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

Objective  The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

Content  1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)
- Solution with the method of characteristics
- Conservation laws

3.) Hyperbolic PDEs
- wave equation
- d'Alembert formula in (1+1)-dimensions
- method of separation of variables

4.) Parabolic PDEs
- heat equation
- maximum principle
- method of separation of variables

5.) Elliptic PDEs
- Laplace equation
- maximum principle
- method of separation of variables
- variational method


Prerequisites / notice  Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

401-0625-01L  Applied Analysis of Variance and Experimental Design

W  5 credits  2V+1U  L. Meier

Abstract  Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective  Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content  Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.


Prerequisites / notice  The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

401-4623-00L  Time Series Analysis

W  4 credits  2G  N. Meinshausen

Abstract  The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective  The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content  This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARIMA, ARIMA, Introduction into GARCH models
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<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Year</th>
<th>Prerequisites /notice</th>
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</thead>
<tbody>
<tr>
<td>401-7855-00L</td>
<td>Computational Astrophysics (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>2V</td>
<td></td>
<td>L. M. Mayer</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: AST245</td>
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<td>Mind the enrolment deadlines at UZH:</td>
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<td><a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline.html">https://www.uzh.ch/cmsssl/en/studies/application/deadline.html</a></td>
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<tr>
<td>Objective</td>
<td>Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes</td>
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| Content     | 1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility  
|             | 2. Large-N gravity calculation, collisionless N-body systems and their simulation  
|             | 3. Fast Fourier Transform and spectral methods in general  
|             | 4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters  
|             | 5. Lagrangian Hydrodynamics: The SPH method  
|             | 6. Resolution and instabilities in Hydrodynamics  
|             | 7. Initial Conditions: Cosmological Simulations and Astrophysical Disks  
|             | 8. Physical Approximations and Methods for Radiative Transfer in Astrophysics |
| Literature  | Galactic Dynamics (Binney & Tremaine, Princeton University Press), Computer Simulation using Particles (Hockney & Eastwood CRC press), Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh) |
| Prerequisites /notice | Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/pythoni as an example), some prior experience programming, knowledge of C. C++ beneficial |

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<th>Prerequisites /notice</th>
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<tr>
<td>402-0809-00L</td>
<td>Introduction to Computational Physics</td>
<td>W</td>
<td>8</td>
<td>2V</td>
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<td>A. Adelmann</td>
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<tr>
<td>Abstract</td>
<td>This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.</td>
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<tr>
<td>Objective</td>
<td>Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.</td>
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<tr>
<td>Content</td>
<td>Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes and slides are available online and will be distributed if desired.</td>
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<tr>
<td>Literature</td>
<td>Literature recommendations and references are included in the lecture notes.</td>
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<td>Prerequisites /notice</td>
<td>Literature recommendations and references are included in the lecture notes.</td>
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<tr>
<td>402-1701-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>7</td>
<td>4V</td>
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<td>W. Wegscheider</td>
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<tr>
<td>Abstract</td>
<td>This course gives a first introduction to Physics with an emphasis on classical mechanics.</td>
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<td>Objective</td>
<td>Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.</td>
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<tr>
<td>Literature</td>
<td><a href="http://www.csb.ethz.ch/education/lectures.html">http://www.csb.ethz.ch/education/lectures.html</a></td>
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<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V</td>
<td></td>
<td>J. Stelling</td>
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<tr>
<td>Abstract</td>
<td>Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).</td>
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<tr>
<td>Objective</td>
<td>The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.</td>
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<tr>
<td>Content</td>
<td>Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label &quot;Systems Biology&quot;, focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) stochastic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.</td>
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<th>ECTS</th>
<th>Year</th>
<th>Prerequisites /notice</th>
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<tbody>
<tr>
<td>651-4241-00L</td>
<td>Numerical Modelling I and II: Theory and Applications</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td></td>
<td>T. Gerya</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasise a hands-on learning approach rather than extensive theory.</td>
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<tr>
<td>Objective</td>
<td>The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.</td>
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</table>
A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity with streamfunction/vorticity formulation. Solving momentum and continuity equations in case of constant viscosity using pressure-velocity formulation with staggered grid.

Week 4: Staggered grid for formulating momentum and continuity equations. Indexing of unknowns. Solving momentum and continuity equations in case of constant viscosity using pressure-velocity formulation with staggered grid.

Weeks 5: Conservative finite differences for the momentum equation. “Free slip” and “no slip” boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radiative, advective and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature

701-0071-00L

Mathematics III: Systems Analysis

W 4 credits 2V+1U

C. Brunner, R. Knutti, S. Schemm, H. Wernli

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance.

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Content
https://iac.ethz.ch/edu/courses/bachelor/vorbereitung/systemanalyse.html

Lecture notes
Overhead slides will be made available through the course website.

701-0901-01L

ETH Week 2022: Urban Futures

W 1 credit 3S

F. Rittiner, S. Brusoni, R. Knutti, S. Menz, A. Vaterlaus

Abstract
All ETH Bachelor’s, Master’s and exchange students can take part in the ETH week. No prior knowledge is required

Objective
ETH Week is an innovative one-week course designed to foster critical thinking and creative learning. Students from all departments as well as professors and external expertise will work together in interdisciplinary teams. They will develop interventions that could play a role in solving some of our most pressing global challenges. In 2022, ETH Week will focus on the topic of urban development.

- Domain-specific knowledge: Students have immersed knowledge about a certain complex, societal topic which will be selected every year. They understand the complex system context of the current topic, by comprehending its scientific, technical, political, social, ecological and economic perspectives.

- Analytical skills: The ETH Week participants are able to structure complex problems systematically using selected methods. They are able to acquire further knowledge and critically analyse the knowledge in interdisciplinary groups with experts and the help of team tutors.

- Design skills: The students are able to use their knowledge and skills to develop concrete approaches for problem-solving and decision making to a selected problem statement, critically reflect on these approaches, assess their feasibility, to transfer them into a concrete form (physical model, prototypes, strategy paper, etc.) and to present this work in a creative way (role-plays, videos, exhibitions, etc.).

- Self-competence: The students are able to plan their work effectively, efficiently and autonomously. By considering approaches from different disciplines they are able to make a judgment and form a personal opinion. In exchange with non-academic partners from business, politics, administration, non-governmental organisations and media they are able to communicate appropriately, present their results professionally and creatively and convince a critical audience.

- Social competence: The students are able to work in multidisciplinary teams, i.e. they can reflect critically on their own discipline, debate with students from other disciplines and experts in a critical-constructive and respectful way and can relate their own positions to different intellectual approaches. They can assess how far they are able to actively make a contribution to society by using their personal and professional talents and skills as “Change Agents”.

- Remote collaboration competence: The students work in a hybrid setting blending physical and virtual communication and collaboration methods and tools. They experience the potential and limitations of remote collaboration.
Didactic Basics for Student Teaching Assistants

**Abstract**
The course "Didactic Basics for Student Teaching Assistants" enhance Student Teaching Assistants (Student TAs) to develop knowledge, capability and confidence to effectively plan and teach courses and exercises. Participants get trained to think critically about students’ learning and create learning situations in which students are actively engaged.

**Objective**
In this course Student Teaching Assistants will...
- reflect on their approach to teaching as well as their attitude towards teaching.
- understand the basics of teaching and learning in the context of their subject.
- consciously design the introduction of their course as well as the introduction of single teaching units.
- apply classroom assessment techniques as formative assessments to measure the current status of their students.
- develop a didactic concept according to the learning objectives.
- conduct interactive sequences as learning activities.
- give and get feedback from peers and self-reflect on their teaching practice.
- feel confident to use methods for active learning scenarios in their classes.

**Content**
The online course provide a range of relevant topics for developing teaching competences of Student Teaching Assistants:
- Overview about how learning works. Based on these fundamentals of learning participants reflect on their role as Student TAs to feel comfortable in their new role as a teacher.
- Plan an own lesson by introducing a class and locate it in the larger topic (methods: portal and informative introduction).
- Develop learning activities in order to activate students (active learning methods).
- Giving and also getting feedback. The participants integrate this topic also in their lesson plan.
- While working through the online course, Student TAs have the chance to reflect, exchange ideas with peers and plan their own teaching accordingly so that they feel confident in their role.

Prerequisites / notice
Self-paced online course: https://moodle-app2.let.ethz.ch/course/view.php?id=17417

Consolidation Workshops at the beginning of November (dates will be announced in the online course at the beginning of the semester)

**Science in Perspective**

**Recommended Science in Perspective (Type B) for D-INFK**

**Language Courses**

**Bachelor’s Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0500-00L</td>
<td>Bachelor’s Thesis</td>
<td>O</td>
<td>10</td>
<td>21D</td>
<td>Professors</td>
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</table>

**Abstract**
The Bachelor thesis is the final requirement of the BSc program and is supervised by one of the D-INFK professors. The thesis encourages students to show and produce a scientifically structured work.

**Objective**
In their BSc thesis students should demonstrate their ability to carry out independent, structured scientific work.

**Prerequisites / notice**
The supervisor of the thesis defines the task, start and end date. A written report will be prepared on the scientific studies carried out, followed by a final presentation. The thesis must be handed in within 6 months.

**Computer Science Bachelor - Key for Type**

- O: Compulsory
- W+: Eligible for credits and recommended
- W: Eligible for credits
- E: Recommended, not eligible for credits
- Z: Courses outside the curriculum
- Dr: Suitable for doctorate
### Key for Hours

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<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Educational Science

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
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<tr>
<td></td>
<td>This lecture is only apt for students who intend to enrol in the programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about learning in childhood and adolescence.</td>
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<td><strong>Abstract</strong></td>
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<td>This course looks into scientific theories and also empirical studies on human learning and relates them to the school.</td>
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<td><strong>Objective</strong></td>
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<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
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<td><strong>Content</strong></td>
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<td>Thematische Schwerpunkte:</td>
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<td>Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzwerbung unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<td><strong>Lecture notes</strong></td>
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<td><strong>Literature</strong></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>This lecture is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
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| 851-0240-22L | Coping with Psychosocial Demands of Teaching (EW4 W D2)               | W    | 2    | 3S    | U. Markwalder, S. Maurer, S. Peteranderl-Rüschoff |
|              | Number of participants limited to 20.                                 |      |      |       |                    |
|              | The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite. |
|              | **Abstract**                                                          |      |      |       |                    |
|              | In this class, students will learn concepts and skills for coping with psychosocial demands of teaching |
|              | **Objective**                                                         |      |      |       |                    |
|              | (1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks). (2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services). |

| 851-0242-05L | Cognitively Activating Instructions in MINT Subjects (EW5 W)          | W    | 2    | 2S    | R. Schumacher      |
|              | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)". |
|              | **Abstract**                                                          |      |      |       |                    |
|              | This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance. |
|              | **Objective**                                                         |      |      |       |                    |
|              | - Get to know cognitively activating instructions in MINT subjects     |      |      |       |                    |
|              | - Get information about recent literature on learning and instruction  |      |      |       |                    |
|              | **Prerequisites / notice**                                            |      |      |       |                    |
|              | Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht. |

| 851-0242-07L | Human Intelligence                                                    | W    | 1    | 1S    | E. Stern          |
|              | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |
|              | Number of participants limited to 30.                                 |      |      |       |                    |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)". |
|              | **Abstract**                                                          |      |      |       |                    |
|              | The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed. |
|              | **Objective**                                                         |      |      |       |                    |
|              | - Understanding of research methods used in the empirical human sciences |      |      |       |                    |
|              | - Getting to know intelligence tests                                 |      |      |       |                    |
|              | - Understanding findings relevant for education                       |      |      |       |                    |

| 851-0242-08L | Research Methods in Educational Science                               | W    | 1    | 2S    | C. M. Thurn, T. Braas, P. Edelsbrunner |
|              | Number of participants limited to 30.                                 |      |      |       |                    |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)". |

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1220 of 2345
In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

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**Gender Issues In Education and STEM**

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>Title</th>
<th>W</th>
<th>credits</th>
<th>ECTS</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>851-0242-11L</td>
<td>W</td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). Prequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.</td>
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</tbody>
</table>

**Abstract**
In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

**Objective**
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives
- To integrate this knowledge with teacher's work.

**Content**
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).
The course "Subject Didactics of Computer Science I" addresses key contributions of computer science to general education. The chosen topics support the young learners in developing a unique and indispensable way of thinking, in enhancing their understanding of our world as well as in achieving university education entrance qualifications.

The main topics of the course unit "Subject Didactics of Computer Science I" are the didactics of finite state automata, of formal languages and of the introduction to programming. The unit focuses on contents of computer science that contribute to general education. This involves the understanding of fundamental scientific concepts such as algorithm, complexity, determinism, computation, automata, verification, testing and programming language as well as the way to embed them into a scientifically sound and didactically sustainable computer science course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes
Unterlagen und Folien werden zur Verfügung gestellt.

Literature
J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen" Lehrwerksreihe "Einfach Informatik"

https://einfachinformatik.inf.ethz.ch/


Lehrdiplo-Studierende müssen diese Lerneinheit zusammen mit dem Einführungspraktikum Informatik - 272-0201-00L - belegen.

Prerequisites / notice
Lehrdiplom-Studierende müssen diese Lerneinheit zusammen mit dem Einführungspraktikum Informatik - 272-0201-00L - belegen.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication assessed</td>
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<td></td>
<td>Cooperation and Teamwork assessed</td>
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<td>Customer Orientation assessed</td>
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<td>Leadership and Responsibility assessed</td>
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<td>Self-presentation and Social Influence assessed</td>
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<td></td>
<td>Sensitivity to Diversity assessed</td>
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<td></td>
<td>Negotiation assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility assessed</td>
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<tr>
<td></td>
<td>Creative Thinking assessed</td>
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<td></td>
<td>Critical Thinking assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management assessed</td>
</tr>
</tbody>
</table>

271-0102-00L Teaching Internship Including Examination Lessons in Computer Science 0 4 credits 9P J. Hromkovic, G. Serafini

Teaching Internship Computer Science for TC.

Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.

Abstract
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>272-0103-00L</td>
<td>Mentored Work Subject Didactics Computer Science O 2 credits 4A J. Hromkovic, G. Serafini</td>
<td>A</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Mentored Work Subject Didactics in Computer Science for TC and Teaching Diploma.</td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.</td>
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<tr>
<td>Objective</td>
<td>The objective is for the students: - to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too. - to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.</td>
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</tr>
<tr>
<td>Content</td>
<td>Thematische Schwerpunkte Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt. Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.</td>
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</table>

**Specialized Courses in Respective Subject with Educational Focus**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>272-0400-00L</td>
<td>Mentored Work Specialised Courses in the Respective Subject with Educational Focus Computer Sc A</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The aim is for the students - to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist-subject competence in this way. - to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership. - To try out different options for specialist further training in their profession.</td>
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</table>

**Concepts of Object-Oriented Programming**

Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection.

Objective

After this course, students will:

- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.
The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing).
- The key problems of single and multiple inheritance and how different languages address them.
- Generic type systems, in particular, Java generics, C# generics, and C++ templates.
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them.
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing.
- How to maintain the consistency of data structures.

Randomized Algorithms and Probabilistic Methods

Abstract
Las Vegas & Monte Carlo algorithms: inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, SSAT, card shuffling, random walks.

Objective
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes
Yes.

Literature

Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous learning algorithms on real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
- Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Design of Parallel and High-Performance Computing

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

**Computer Science TC - Key for Type**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Recommended, not eligible for credits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td></td>
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</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Letter</th>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

Abstract
This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
Für eine reibunglose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

**Educational Science**

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-06L</td>
<td><strong>Cognitively Activating Instructions in MINT Subjects</strong>&lt;br/enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).&lt;br/number of participants limited to 30.&lt;br&gt;this course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**
The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

**Objective**
- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

**Prerequisites / notice**
This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

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**Educational Science Teaching Diploma**

More information at: https://www.ethz.ch/de/studium/didaktische-ausbildung/studienangebot-zulassung/lehrdiplom-fuer-maturitaetsschulen.html

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<tbody>
<tr>
<td>851-0242-07L</td>
<td><strong>Human Intelligence</strong>&lt;br/enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).&lt;br/number of participants limited to 30.&lt;br&gt;this course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**
This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

**Objective**
- Understanding research methods used in the empirical educational sciences
- Understanding and critically examine information from scientific journals and media
- Understanding pedagogically relevant findings from the empirical educational sciences

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**Support and Diagnosis of Knowledge Acquisition Processes (EW3)**

Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the "Teaching Diploma".

**Prerequisites / notice**
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).
Prerequisites: successful participation in 851-0240-00L “Human Learning (EW1)”.

Abstract
In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

Objective
The main goals are:
(1) You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
(2) You have a basic understanding about psychological test theory and can appropriately administer tests.
(3) You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

Subject Didactics in Computer Science
Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>272-0101-00L</td>
<td>Subject Didactics of Computer Science I</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>G. Serafini, J. Hromkovic</td>
</tr>
</tbody>
</table>

Abstract
The unit “Subject Didactics of Computer Science I” addresses key contributions of computer science to general education. The course deals with the thoughtful choice of educational contents for computer science classes, which takes into account its comprehensibility for different age groups as well as didactic approaches suitable for a successful knowledge transfer.

Objective
The general objective of the course consists in highlighting the tight connection between the mathematical and algorithmic way of thinking and the approaches adopted by engineering disciplines, and in reflecting on teaching approaches for sustainable computer science teaching activities.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

Content
The course “Subject Didactics of Computer Science I” addresses key contributions of computer science to general education. The chosen topics support the young learners in developing a unique and indispensable way of thinking, in enhancing their understanding of our world as well as in achieving university education entrance qualifications.

The main topics of the course unit “Subject Didactics of Computer Science I” are the didactics of finite state automata, of formal languages and of the introduction to programming. The unit focuses on contents of computer science that contribute to general education. This involves the understanding of fundamental scientific concepts such as algorithm, complexity, determinism, computation, automata, verification, testing and programming language as well as the way to embed them into a scientifically sound and didactically sustainable computer science course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes
Unterlagen und Folien werden zur Verfügung gestellt.

Literature
J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen"
Lehrwerksreihe "Einfach Informatik"
https://einfachinformatik.inf.ethz.ch/


Prerequisites / notice
Lehrdiplom-Studierende müssen diese Lerneinheit zusammen mit dem Einführungspraktikum Informatik - 272-0201-00L - belegen.

Data: 18.08.2022 12:39   Autumn Semester 2022   Page 1227 of 2345
Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird

### Methodische Schwerpunkte

**Concepts and Theories**

**Techniques and Technologies**

**Analytical Competencies**

**Decision-making**

**Media and Digital Technologies**

**Problem-solving**

**Project Management**

**Communication**

**Cooperation and Teamwork**

**Customer Orientation**

**Leadership and Responsibility**

**Self-presentation and Social Influence**

**Sensitivity to Diversity**

**Negotiation**

**Adaptability and Flexibility**

**Creative Thinking**

**Critical Thinking**

**Integrity and Work Ethics**

**Self-awareness and Self-reflection**

**Self-direction and Self-management**

### Personal Competencies

**Method-specific Competencies**

**Social Competencies**

**Personal Competencies**

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical Competencies</th>
<th>Method-specific Competencies</th>
<th>Analytical and Decisional Competencies</th>
<th>Social and Personal Competencies</th>
</tr>
</thead>
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<td>Taught competencies</td>
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</tr>
<tr>
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<td>2 credits</td>
<td>Taught competencies</td>
<td>2 credits</td>
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</tbody>
</table>

### Mentored Work Subject Didactics Computer Science

#### A

- **Number:** 272-0103-00L
- **Title:** Mentored Work Subject Didactics Computer Science
- **ECTS:** 4A
- **Credit:** 2
- **Author:** J. Hromkovic, G. Serafini

#### Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

#### Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

#### Content

**Thematische Schwerpunkte**

Die Arbeitspraktikum in Fachdidaktik stammt in der Regel aus dem gymnasialen Unterricht.

**Lernformen**


**Literatur**

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

**Prerequisites / notice**

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

#### B

- **Number:** 272-0104-00L
- **Title:** Mentored Work Subject Didactics Computer Science
- **ECTS:** 4A
- **Credit:** 2
- **Author:** J. Hromkovic, G. Serafini

#### Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

#### Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

#### Content

**Thematische Schwerpunkte**

Die Arbeitspraktikum in Fachdidaktik stammt in der Regel aus dem gymnasialen Unterricht.

**Lernformen**


**Literatur**

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

**Prerequisites / notice**

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

### Professional Training

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

#### Number

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tr>
<td>272-0201-00L</td>
<td>Introductory Practical in Computer Science</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
</tbody>
</table>

#### Abstract

During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.
Die Studierenden können die Bedeutung von Unterrichtsthemen in ihrem Fach unter verschiedenen Blickwinkeln einschätzen. Sie kennen

achievements of additional school-relevant experiences. The students carry out individually specified, practice related projects, in which they support, document or reflect on learning processes.

Objective
Achievement of additional school-relevant experiences. The students carry out individually specified, practice related projects, in which they support, document or reflect on learning processes.

Content
The course Professional Exercises offers the opportunity for additional school-relevant activities. The students are supported by the lecturers or by experienced teachers. They assist teachers at school, they create training systems and tests, correct the written homework of pupils and evaluate the progress of a class. The students create explanations and detailed solutions to exercises with respect to the actual knowledge of the pupils. A written assignment states the exact scope of the activity.

Literature
Wird von der Praktikumslehrperson bestimmt.

272-0202-00L
Professional Exercises

Objective
Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training.

Content
The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Abstract
In the course Professional Exercises the students achieve additional school-relevant experiences. The students carry out individually specified, practice related projects, in which they support, document or reflect on learning processes.

272-0203-00L
Teaching Internship in Computer Science

Objective
- The students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Literature
Wird von der Praktikumslehrperson bestimmt.

272-0204-00L
Teaching Internship for students upgrading TC to Teaching Diploma

Objective
Die Studierenden können die Bedeutung von Unterrichtsthemen in ihrem Fach unter verschiedenen Blickwinkeln einschätzen. Sie kennen und beherrschen das unterrichtliche Handwerk. Sie können ein gegebenes Unterrichtsthema für eine Gruppe von Lernenden fachlich und didaktisch korrekt strukturieren und in eine adäquate Lernumgebung umsetzen. Es gelingt ihnen, die Balance zwischen Anleitung und Offenheit zu finden, sodass die Lernenden sowohl über den nötigen Freiraum wie über ausreichend Orientierung verfügen, um aktiv und effektiv flexibel nutzbares (Fach-)Wissen zu erwerben.

Content

272-0205-01L
Examination Lesson I in Computer Science

Objective
On the basis of a specified topic, the candidate shows that they are in a position
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Content

Lecture notes
Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

Prerequisites / notice
Nach Abschluss der übrigen Ausbildung.

272-0205-02L
Examination Lesson II in Computer Science

Objective
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Content
Simultaneous enrolment in "Examination Lesson II in Computer Science" (272-0205-02L) is compulsory.

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Lecture notes
Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

Prerequisites / notice
Nach Abschluss der übrigen Ausbildung.
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Number</strong></td>
</tr>
<tr>
<td>272-0400-00L</td>
</tr>
<tr>
<td>272-0401-00L</td>
</tr>
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<td></td>
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</tbody>
</table>
| Objective | On the basis of a specified topic, the candidate shows that they are in a position  
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle  
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements. | | | | |
| Lecture notes | | | | | |
| Prerequisites / notice | | | | | |
| | | | | | |
| 252-0237-00L | Concepts of Object-Oriented Programming | W | 8 credits | 3V+2U+2A | P. Müller |
| | Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection | | | | |
| Objective | After this course, students will:  
Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.  
Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.  
Be able to learn new languages more rapidly.  
Be aware of many subtle problems of object-oriented programming and know how to avoid them. | | | | |
| Content | The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.  
The topics discussed in the course include among others:  
The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)  
The key problems of single and multiple inheritance and how different languages address them  
Generic type systems, in particular, Java generics, C# generics, and C++ templates  
The situations in which object-oriented programming does not provide encapsulation, and how to avoid them  
The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing  
How to maintain the consistency of data structures | | | | |
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Randomized Algorithms and Probabilistic Methods

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics

3V+2U+3A

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
What is data?
Bayesian Learning
Computational learning theory

Supervised learning:
Ensembles: Bagging and Boosting
Max Margin methods
Neural networks

Unsupervised learning:
Dimensionality reduction techniques
Clustering
Mixture Models
Non-parametric density estimation
Learning Dynamical Systems

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

The course is accompanied by practical machine learning projects.

Design of Parallel and High-Performance Computing

Number of participants limited to 125.

Advanced topics in parallel and high-performance computing. We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

see Compulsory Elective Courses Teaching Diploma
### Computer Science Teaching Diploma - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
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<tbody>
<tr>
<td>V</td>
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</tr>
<tr>
<td>G</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.

Large scale analytics and machine learning are outside of the scope of this course.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. Experience for solving assignments.

The list of papers will be provided at the beginning of the course.

Advanced Machine Learning

Objective
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understating these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

252-0535-00L Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

No lecture notes, but slides will be made available on the course webpage.

Topics covered in the lecture include:

Fundamentals:
What is data?
Bayesian Learning
Computational learning theory

Supervised learning:
Ensembles: Bagging and Boosting
Max Margin methods
Neural networks

Unsupervised learning:
Dimensionality reduction techniques
Clustering
Mixture Models
Non-parametric density estimation
Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.


Prerequisites / notice
The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

ECTS
7 credits

No lecture notes, but slides will be made available on the course webpage.

The list of papers will be provided at the beginning of the course.

Along the lectures, model cases will be elaborated and evaluated in the exercises.

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

assessed
assessed

Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>W</td>
<td>7 credits</td>
<td>2V+2U+2A</td>
<td>S. Capkun, S. Shinde</td>
</tr>
<tr>
<td>Abstract</td>
<td>The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.</td>
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</tr>
<tr>
<td>Content</td>
<td>The first part of the lecture covers individual system's aspects starting with tamperproof or tamperresistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc. In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).</td>
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</table>

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1234 of 2345
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations. Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Number of participants limited to 320.

Abstract

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Objective

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or TensorFlow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

- Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/
- Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/
- Introduction to Machine Learning
  https://ias.inf.ethz.ch/teaching/introml-S19
- Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/
- Computational Statistics
  https://stat.ethz.ch/lectures/ss19/compp-stats.php
- Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-f18

Informal Methods

Formal methods are increasingly a key part of the methodological toolkit of systems programmers - those writing operating systems, databases, and distributed systems. This course is about how to apply concepts, techniques, and principles from formal methods to such software systems, and how to get into the habit of thinking formally about systems design even when writing low-level C code.

Objective

This course is about equipping students whose focus is systems with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers. By the end of the course, students should be able to seamlessly integrate basic concepts from formal methods into how they conceive, design, implement, reason about, and debug computer systems.

The goal is not to provide a comprehensive introduction to formal methods - this is well covered by other courses in the department. Instead, it is intended to provide students in computer systems (who may or may not have existing background knowledge of formal methods) with a basis for applying formal methods in their work.

Content

This course does not assume prior knowledge of formal methods, and will start with a quick review of topics such static vs. dynamic reasoning, variants and invariants, program algebra and refinement, etc. However, it is strongly recommended that students have already taken one of the introductory formal methods course at ETH (or equivalents elsewhere) before taking this course - the emphasis is on reinforcing these concepts by applying them, not to teach them from scratch.

Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified sat4j microkernel will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).

Major in Machine Intelligence

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3+2+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Literature**

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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**263-3210-00L Deep Learning**  
W 8 credits 3V+2U+2A  
T. Hofmann, F. Perez Cruz  

**Abstract**  
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**  
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is to gain a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  1. Advanced Machine Learning  
     https://ml2.inf.ethz.ch/courses/aml/
  2. Computational Intelligence Lab  
     http://da.inf.ethz.ch/teaching/2019/CIL/
  3. Introduction to Machine Learning  
     https://las.inf.ethz.ch/teaching/introml-S19
  4. Statistical Learning Theory  
     http://ml2.inf.ethz.ch/courses/stl/
  5. Computational Statistics  
     https://stat.ethz.ch/lectures/ss19/comp-stats.php
  6. Probabilistic Artificial Intelligence  
     https://las.inf.ethz.ch/teaching/pai-f18

---

**263-5210-00L Probabilistic Artificial Intelligence**  
W 8 credits 3V+2U+2A  
A. Krause  

**Abstract**  
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**  
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

### Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-3005-00L</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7 credits</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
</tr>
<tr>
<td>263-5005-00L</td>
<td>Artificial Intelligence in Education</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>M. Sachan, T. Sinha</td>
</tr>
</tbody>
</table>

**Abstract**

This presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Objective**

The objective of the course is to learn the basic concepts in the statistical processing of natural language. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

**Content**

The course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Literature**

Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

**Prerequisites / notice**


- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.

For solving assignments, some programming experience in Python is expected.
Foundations of Reinforcement Learning

Non-Prerequisites

The course will be offered again in FS23.

Objective

This course aims to provide students with an advanced introduction to RL theory and algorithms as well as bring them near the frontier of this active research field.

Content

Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming, and primal-dual perspectives of RL, model-based and model-free RL, policy gradient, and actor-critic algorithms, Markov games, and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes

Lecture notes will be posted on Moodle.

Literature

Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepesvári.

Prerequisites / notice

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

Guarantees for Machine Learning

Non-Prerequisites

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective

By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks, and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression", "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Taught competencies

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH).

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Problem-solving

Method-specific Competencies

- Communication
- Cooperation and Teamwork

Social Competencies

- Creative Thinking
- Critical Thinking

Personal Competencies

- assessed
- assessed
- assessed
- assessed

Philosophy of Language and Computation

Non-Prerequisites

Understand the philosophical underpinnings of language-based artificial intelligence.

Objective

This course aims to provide students with an advanced introduction to RL theory and algorithms as well as bring them near the frontier of this active research field.

Content

Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming, and primal-dual perspectives of RL, model-based and model-free RL, policy gradient, and actor-critic algorithms, Markov games, and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes

Lecture notes will be posted on Moodle.

Literature

Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepesvári.

Prerequisites / notice

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.
This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data.

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
The key problems of single and multiple inheritance and how different languages address them
Generic type systems, in particular, Java generics, C# generics, and C++ templates
The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
How to maintain the consistency of data structures

The literature will be provided by the instructors on the class website.

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

### Major in Secure and Reliable Systems

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8</td>
<td>3+2U+2A</td>
<td>P. Müller</td>
</tr>
<tr>
<td>Abstract</td>
<td>Course focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection</td>
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<tr>
<td>Objective</td>
<td>After this course, students will:</td>
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<tr>
<td></td>
<td>Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.</td>
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<td></td>
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<td></td>
<td>Be aware of many subtle problems of object-oriented programming and know how to avoid them.</td>
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<tr>
<td>Content</td>
<td>The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.</td>
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<tr>
<td>Literature</td>
<td>Will be announced in the lecture.</td>
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<tr>
<td>Prerequisites</td>
<td>Prerequisites:</td>
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<td></td>
<td>Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience</td>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7</td>
<td>2+2U+2A</td>
<td>D. Basin, M. Ochoa Ronderos</td>
</tr>
<tr>
<td>Abstract</td>
<td>Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements &amp; risk analysis, system modeling &amp; model-based development methods, implementation-level security, and evaluation criteria for secure systems</td>
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<tr>
<td>Objective</td>
<td>Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data. The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.</td>
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<tr>
<td>Literature</td>
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<td>Prerequisites</td>
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The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class

2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security

3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts

4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience

5. Model-driven security (Part II)
   - Continuation of above topics

6. Security patterns (design and implementation)

7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks

8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis

9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties

10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment

11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience

12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection

13. Guest lecture
    - TBA

Literature

- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice

Prerequisite: Class on Information Security

System Security

The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

The first part of the lecture covers individual system’s aspects starting with tamperproof or tamperresistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include; patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthly computing (TCG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-2800-00L Design of Parallel and High-Performance Computing  W  9 credits  3V+2U+3A  T. Hoefler, M. Püschel
Number of participants limited to 125.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This course is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-4640-00L Network Security  W  8 credits  2V+2U+3A  A. Perrig, S. Frei, M. Legner, K. Paterson

Abstract
Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
1. (1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. (2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. (3) analysis and inference topics such as traffic monitoring and network forensics; and
4. (4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Taught competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

Elective Courses

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>252-1411-00L</td>
<td>Security of Wireless Networks</td>
<td>W</td>
<td>6</td>
<td>2V+1U+2A</td>
<td>S. Capkun, K. Kostiainen</td>
</tr>
</tbody>
</table>

Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.
After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.


Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

The course is split into 3 parts:

Robustness in Deep Learning

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Public-Key Encryption has had a significant impact by enabling remote parties to communicate securely via an insecure channel. Latest schemes go further by providing a fine-grained access to the encrypted data.

The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.

We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

More advanced constructions of non-interactive proofs. The course may also describe some more advanced constructions of non-interactive proofs.

While not a formal requirement, the course assumes familiarity with the basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Zero-knowledge proofs are protocols which allow a prover to convince a verifier that a statement is true without leaking any information beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.

The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in cryptography and the real world. The course may also describe some more advanced constructions of non-interactive proofs.

This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.
Objective
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:

- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.
- writing critical reviews and constructive discussions with peers on this topic.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature
Slides, relevant literature and manuals will be made available during the course.

Prerequisites / notice
Experience with Linux, systems programming and computer architecture.

Major in Theoretical Computer Science
Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>A. Steger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Las Vegas &amp; Monte Carlo algorithms; inequalities of Markov, Chebyshiev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks. After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas. Randomized Algorithms are algorithms that &quot;flip coins&quot; to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas. Yes.</td>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
<tr>
<td>Abstract</td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects. Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data. The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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<tr>
<td>Content</td>
<td>Topics covered in the lecture include: Fundamentals: What is data? Bayesian Learning Computational learning theory Supervised learning: Ensembles: Bagging and Boosting Max Margin methods Neural networks Unsupervised learning: Dimensionality reduction techniques Clustering Mixture Models Non-parametric density estimation Learning Dynamical Systems</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least &quot;Introduction to Machine Learning&quot; or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.</td>
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<tr>
<td>252-1425-00L</td>
<td>Geometry: Combinatorics and Algorithms</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>B. Gärtner, E. Welzl, M. Hoffmann</td>
</tr>
<tr>
<td>Abstract</td>
<td>Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)</td>
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</tbody>
</table>
The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Objective

Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in $\mathbb{R}^d$, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Content

Lecture notes

Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in $\mathbb{R}^d$, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Literature


Prerequisites / notice

Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>A. Lapidoth</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.</td>
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<tr>
<td>Objective</td>
<td>The fundamentals of Information Theory including Shannon's source coding and channel coding theorems</td>
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<tr>
<td>Content</td>
<td>The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity</td>
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<tr>
<td>Literature</td>
<td>T.M. Cover and J. Thomas, Elements of Information Theory (second edition)</td>
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<tr>
<td>263-5300-00L</td>
<td>Guarantees for Machine Learning</td>
<td>W</td>
<td>7</td>
<td>3V+1U+2A</td>
<td>F. Yang, A. Sanyal</td>
</tr>
<tr>
<td>Number of participants limited to 30.</td>
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<tr>
<td>Abstract</td>
<td>This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.</td>
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<tr>
<td>Objective</td>
<td>By the end of the semester students should be able to</td>
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<tr>
<td>Content</td>
<td>- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work</td>
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<td>- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions</td>
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<td>- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in individual exercises, homework, and projects in the final project</td>
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<td>- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as &quot;Introduction to Machine Learning&quot;, &quot;Regression&quot; or &quot;Statistical Modelling&quot;. In addition to these prerequisites, this course requires a high level of mathematical maturity— including abstract thinking and the ability to understand and write proofs.</td>
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<tr>
<td>Taught competencies</td>
<td>Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)</td>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories, assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies, assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication, assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking, assessed</td>
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</table>

401-3054-14L  Probabilistic Methods in Combinatorics  W  6 credits  2V+1U  B. Sudakov

Abstract

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

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The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems. We expect the students to understand the proof techniques and to use them autonomously on related problems.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure $A$ one maps its elements to vectors in a linear space, and shows that the set $A$ is mapped to linearly independent vectors. It then follows that the cardinality of $A$ is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Equivalence between optimization and separation.
- Combinatorial optimization problems and polyhedral techniques;
- Flows and cuts;
- Linear programming and polyhedra;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.
- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Students are expected to have a mathematical background and should be able to write rigorous proofs.

401-3901-00L  Linear & Combinatorial Optimization  11 credits  4V+2U  R. Zenklusen

Abstract  Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective  The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content  Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Prerequisites / notice  Former course title: Mathematical Optimization.

401-3055-64L  Algebraic Methods in Combinatorics  6 credits  2V+1U  B. Sudakov

Does not take place this semester.

Abstract  Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective  The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content  Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

The topics covered in the class will include (but are not limited to):

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

Prerequisites / notice  Students are expected to have a mathematical background and should be able to write rigorous proofs.
This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

**Objective**
At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

**Content**
This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

**Lecture notes**
no

**Literature**
Books:
High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting

Multiple view geometry in computer vision

Physically Based Rendering: From Theory to Implementation

**Prerequisites / notice**
Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.

The programming assignments will be in C++. This will not be taught in the class.

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### Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0543-01L</td>
<td>Computer Graphics</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>M. Gross, M. Papas</td>
</tr>
</tbody>
</table>

**Abstract**
This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

**Objective**
At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

**Content**
This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

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### Seminar

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-3811-00L</td>
<td>Case Studies from Practice Seminar</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>M. Brandis</td>
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</tbody>
</table>

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

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Autumn Semester 2022
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Abstract
Participants will learn how to analyze and solve IT problems in practice in a systematic way, present findings to decision bodies, and defend their conclusions.

Objective
Participants understand the different viewpoints for IT-decisions in practice, including technical and business aspects, can effectively analyze IT questions from the different viewpoints and facilitate decision making.

Content
Participants learn how to systematically approach an IT problem in practice. They work in groups of three to solve a case from a participating company in depth, studying provided materials, searching for additional information, analyzing all in depth, interviewing members from the company or discussing findings with them to obtain further insights, and presenting and defending their conclusion to company representatives, the lecturer, and all other participants of the seminar. Participants also learn how to challenge presentations from other teams, and obtain an overview of learnings from the cases other teams worked on.

Lecture notes / notice
Methodologies to analyze the cases and create final presentations. Short overview of each case.

Prequisites / Literature
Successful completion of Lecture "Case Studies from Practice".

252-4601-00L  Current Topics in Information Security

<table>
<thead>
<tr>
<th>Content</th>
<th>Objective</th>
<th>Abstract</th>
<th>Literature</th>
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<tbody>
<tr>
<td></td>
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<td>The seminar covers various topics in information security: security protocols (models, specification &amp; verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.</td>
<td>The main goals of the seminar are the independent study of scientific literature and assessment of its contributions as well as learning and practicing presentation techniques.</td>
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<table>
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<tr>
<th>Prerequisites</th>
<th>Literature</th>
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<table>
<thead>
<tr>
<th>Selected Topics</th>
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<tbody>
<tr>
<td>- security protocols: models, specification &amp; verification</td>
</tr>
<tr>
<td>- trust management, access control and non-interference</td>
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<td>- side-channel attacks</td>
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<td>- identity-based cryptography</td>
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<td>- host-based attack detection</td>
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<td>- anomaly detection in backbone networks</td>
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<td>- key-management for sensor networks</td>
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252-5051-00L  Advanced Topics in Machine Learning

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<tr>
<th>Content</th>
<th>Objective</th>
<th>Abstract</th>
<th>Literature</th>
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<tr>
<td></td>
<td></td>
<td>The seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics.</td>
<td>The seminar &quot;Advanced Topics in Machine Learning&quot; familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.</td>
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<table>
<thead>
<tr>
<th>Prerequisites</th>
<th>Literature</th>
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<table>
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<tr>
<th>Selected Topics</th>
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<tbody>
<tr>
<td>- computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.</td>
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<tr>
<td>- learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from data mining, image processing, natural language processing, statistical models in computer vision, graphical models and machine learning.</td>
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</table>

252-5701-00L  Seminar in Advanced Topics in Vision

<table>
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<tr>
<th>Content</th>
<th>Objective</th>
<th>Abstract</th>
<th>Literature</th>
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<tr>
<td></td>
<td></td>
<td>This seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics.</td>
<td>The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve presentations and critical analysis skills.</td>
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<table>
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<tr>
<th>Prerequisites</th>
<th>Literature</th>
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<table>
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<tr>
<th>Selected Topics</th>
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<tbody>
<tr>
<td>- classical and state-of-the-art papers.</td>
</tr>
<tr>
<td>- papers are selected covering topics such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction and others. Each student presents one paper to the class and leads a discussion about the paper and related topics.</td>
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</tbody>
</table>

263-2100-00L Research Topics in Software Engineering

<table>
<thead>
<tr>
<th>Content</th>
<th>Objective</th>
<th>Abstract</th>
<th>Literature</th>
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<tbody>
<tr>
<td></td>
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<td>Individual research papers are selected each term.</td>
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</table>

<table>
<thead>
<tr>
<th>Prerequisites</th>
<th>Literature</th>
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<table>
<thead>
<tr>
<th>Selected Topics</th>
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<tbody>
<tr>
<td>- key-management for sensor networks</td>
</tr>
</tbody>
</table>

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Abstract
This seminar is an opportunity to become familiar with current research in software engineering and more generally with the methods and challenges of scientific research. Each student will be asked to study some papers from the recent software engineering literature and review them. This is an exercise in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

Content
The aim of this seminar is to introduce students to recent research results in the area of programming languages and software engineering. To accomplish that, students will study and present research papers in the area as well as participate in paper discussions. The papers will span topics in both theory and practice, including papers on program verification, program analysis, testing, programming language design, and development tools. A particular focus will be on domain-specific languages.

Prerequisites / notice
Organizational note: the seminar will meet only when there is a scheduled presentation. Please consult the seminar's home page for information.

263-3504-00L Hardware Acceleration for Data Processing
Number of participants limited to 24.

Abstract
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Objective
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Content
The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

Prerequisites / notice
Students taking this seminar should have the necessary background in systems and low level programming.

263-3713-00L Advanced Topics in Human-Centric Computer Vision
Number of participants limited to 20.

Abstract
In this seminar we will discuss state-of-the-art literature on human-centric computer vision topics including but not limited to human pose estimation, hand and eye-gaze estimation as well as generative modeling of detailed human activities.

Objective
The learning objective is to analyze selected research papers published at top computer vision and machine learning venues. A key focus will be placed on identifying and discussing open problems and novel solutions in this space. The seminar will achieve this via several components: reading papers, technical presentations, writing analysis and critique summaries, class discussions, and exploration of potential research topics.

Content
The goal of the seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and oral presentation skills. The seminar will have a different structure from regular seminars to encourage more discussion and a deeper learning experience.

We will treat papers as case studies and discuss them in-depth in the seminar. Once per semester, every student will have to take one of the following roles:

Presenter: Give a presentation about the paper that you read in depth.

Reviewer: Perform a critical review of the paper.

All other students: read the paper and submit questions they have about the paper before the presentation.

Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.

Prerequisites / notice

263-4410-00L Seminar on Advanced Graph Algorithms and Optimization
Number of participants limited to 6/

Abstract
This seminar aims to familiarize students with current research topics in fast graph algorithms and optimization. We will study recent papers that made significant contributions in the areas in fast graph algorithms and optimization.

Objective
Read papers on cutting edge research topics; learn how to give a scientific talk.

Content
As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

Prerequisites / notice

263-5100-00L Topics in Medical Machine Learning
Number of participants limited to 18.

Abstract
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Objective
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Content
The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

Prerequisites / notice

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

The deadline for deregistering expires at the end of the fourth week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

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This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold a presentation and lead the subsequent discussion.

Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.

The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

2022-0811-00L  Applied Security Laboratory  W  8 credits  7P  J. Gómez Luna

Abstract: Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

Objective: The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, logging), application security with an emphasis on web security (web server setup, common web exploits, authentication, session handling, code security), computer forensics, and risk analysis and risk management.

Content: This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectiveness and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.

Prerequisites / notice
Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice.

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<th>Number</th>
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<tr>
<td>252-0811-00L</td>
<td>Applied Security Laboratory</td>
<td>W</td>
<td>8</td>
<td>7P</td>
<td>D. Basin</td>
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</table>

252-0811-00L  Applied Security Laboratory  W  8 credits  7P  D. Basin

Abstract: Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

Objective: The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, logging), application security with an emphasis on web security (web server setup, common web exploits, authentication, session handling, code security), computer forensics, and risk analysis and risk management.

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252-0811-00L  Applied Security Laboratory  W  8 credits  7P  D. Basin

Abstract: Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

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Content: This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectiveness and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

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<td>252-0811-00L</td>
<td>Applied Security Laboratory</td>
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<td>7P</td>
<td>D. Basin</td>
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</table>
Recommended reading includes:

* Scambray, Scheiner, Smith: Hacking: The Art of Exploitation, Addison-Wesley.
* Beckman, Halstead, et al.: Design Patterns: Elements of Reusable Object-Oriented Software, Addison-Wesley.
* NIST: Risk Management Guide for Information Technology Systems, available online as PDF
* BSI: Grundschutzhandbuch, available online

Prerequisites / notice
* The lab allows flexible working since there are only few mandatory meetings during the semester.
* The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas: information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.
* Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the recommended requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.
* All participants must sign the lab's charter and usage policy during the introduction lecture.

252-0817-00L Distributed Systems Laboratory

Abstract
This course covers some of the fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and texture capture, light-fields and depth-image based rendering.

Objective
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Content
This course involves the participation in a substantial development and/or evaluation project involving distributed systems technology. There are projects available in a wide range of areas: from web services to ubiquitous computing including wireless networks, ad-hoc networks, RFID, and distributed applications on smartphones.

263-0650-00L Practical Work

Abstract
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective
Gain hands-on-experience with real products and the latest technology in distributed systems.

Content
This course involves the participation in a substantial development and/or evaluation project involving distributed systems technology. There are projects available in a wide range of areas: from web services to ubiquitous computing including as well wireless networks, ad-hoc networks, and distributed application on smartphones. The goal of the project is for the students to gain hands-on-experience with real products and the latest technology in distributed systems. There is no lecture associated to the course.

Minor in Computer Graphics

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>252-0546-00L</td>
<td>Physically-Based Simulation in Computer Graphics</td>
<td>5</td>
<td>2V+1U+1A</td>
</tr>
<tr>
<td>252-0543-01L</td>
<td>Computer Graphics</td>
<td>8</td>
<td>3V+2U+2A</td>
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</table>

Literature
Books:
High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
Multiple view geometry in computer vision
Physically Based Rendering: From Theory to Implementation

Prerequisites
Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1250 of 2345
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

### Minor in Computer Vision

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<tr>
<th>Number</th>
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<tr>
<td>263-3210-00L</td>
<td>Deep Learning</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>T. Hofmann, F. Perez Cruz.</td>
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**Abstract**
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

**Prerequisites / notice**
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://ias.inf.ethz.ch/teaching/introml-s19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-118

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### Minor in Computer Graphics

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<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
</tr>
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</table>

**Abstract**
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

**Objective**
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Content**
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

**Prerequisites / notice**
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

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### Minor in Mixed Reality

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<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>W</td>
<td>5 credits</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
</tr>
</tbody>
</table>

**Abstract**
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

**Objective**
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

**Content**
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1251 of 2345
Prerequisites / notice
Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

Minor in Data Management

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<th>Number</th>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

263-2800-00L Design of Parallel and High-Performance Computing W 9 credits 3V+2U+3A T. Hoefler, M. Püschel

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3010-00L Big Data W 10 credits 3V+2U+4A G. Fourny

Abstract
The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.
Objective

This combination of requirements, together with the technologies that have emerged in order to address them, is typically referred to as "Big Data." This revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it were and are still needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each business use case efficiently and consistently.

Content

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters; starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (? , *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Literature

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2021

There is no hard dependency, so you can either take them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

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**263-3210-00L Deep Learning**

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<th>W 8 credits</th>
<th>Number of participants limited to 320.</th>
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<tr>
<td>3V+2U+2A</td>
<td>T. Hofmann, F. Perez Cruz, N. Perraudin</td>
</tr>
</tbody>
</table>

**Abstract**

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation versus interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below.

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7 credits</td>
<td>2V+2U+2A</td>
<td>D. Basin, M. Ochoa Ronderos</td>
</tr>
</tbody>
</table>

Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.
Objective

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems
Content

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class

2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security

3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts

4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience

5. Model-driven security (Part II)
   - Continuation of above topics

6. Security patterns (design and implementation)

7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks

8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis

9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties

10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment

11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience

12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection

13. Guest lecture
    - TBA

Literature

- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice

Prerequisite: Class on Information Security

252-1411-00L Security of Wireless Networks W 6 credits 2V+1U+2A S. Capkun, K. Kostlainen

Abstract

Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1256 of 2345
Objective
After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.

Content

252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde
Abstract
The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over operating system related security mechanisms to application software systems, such as host based intrusion detection systems. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers individual system's aspects starting with tamperproof or tamperresistant hardware in general over operating system related security mechanisms to application software systems such as host based intrusion detection systems. The main topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security (permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management, common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security, language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TCG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-4640-00L Network Security W 8 credits 2V+2U+3A A. Perrig, S. Frei, M. Legner, K. Paterson
Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
1) network defense mechanisms such as public-key infrastructures, TLS, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3) analysis and inference topics such as traffic monitoring and network forensics; and
4) new technologies related to next-generation networks.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management assessed

263-4657-00L Advanced Encryption Schemes W 5 credits 2V+1U+1A R. Gay
Abstract
Public-Key Encryption has had a significant impact by enabling remote parties to communicate securely via an insecure channel. Latest schemes go further by providing a fine-grained access control to the encrypted data.

Objective
The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.

Content
We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Literature
Links to relevant research papers will be given in the course materials.

Prerequisites / notice
It is recommended for students to have prior exposure to cryptography, e.g. the D-INFK course "Digital Signatures" or "Applied Cryptography".

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1257 of 2345
To understand what it means for a zero-knowledge proof to be secure, slides, relevant literature, and manuals will be made available during the course. Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics, and exploratory data analysis. This course is accompanied by practical machine learning projects.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation

- Learning Dynamical Systems

Lecture notes: No lecture notes, but slides will be made available on the course webpage. Literature:


Prerequisites / notice: The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.
Objective
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

263-2400-00L Reliable and Trustworthy Artificial Intelligence W 6 credits 2V+2U+1A M. Vechev

Abstract
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

Content
- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning
- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning
- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


Prerequisites / notice
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
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<td>assessed</td>
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<tr>
<td>Problem-solving</td>
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<td>assessed</td>
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<tr>
<td>Creative Thinking</td>
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<td>assessed</td>
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<tr>
<td>Critical Thinking</td>
<td></td>
<td>assessed</td>
</tr>
</tbody>
</table>

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz, N. Perraudin

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  - Advanced Machine Learning
    https://mi2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://mi2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/s19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
</table>
| 263-5005-00L | Artificial Intelligence in Education | 3       | Solid basic knowledge in statistics, algorithms and programming. | The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques. | Topics covered:  
- Probability  
- Probabilistic inference (variational inference, MCMC)  
- Bayesian learning (Gaussian processes, Bayesian deep learning)  
- Probabilistic planning (MDPs, POMDPs)  
- Multi-armed bandits and Bayesian optimization  
- Reinforcement learning  
- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic. |
Prerequisites / notice

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5300-00L Guarantees for Machine Learning

Number of participants limited to 30.

Abstract

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in independent exercises and potentially in the final project

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- over-parameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/ "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Taught competencies

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analysis and Competencies

Problem-solving

Analytical Competencies

Social Competencies

Communication

Cooperation and Teamwork

Personal Competencies

Creative Thinking

Critical Thinking

263-5353-00L Philosophy of Language and Computation

Number of participants limited to 30.

Abstract

This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data. In addition to these prerequisites, this class requires a high degree of mathematical maturity—perhaps implicitly or unwittingly.

Objective

This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data. The course is a year-long journey, but the second half (Spring 2023) does not depend on the first (Fall 2022) and thus either half may be taken independently. In each semester, we divide the class time into three modules. Each module is centered around a philosophical topic. In the first semester we will discuss structuralism, recursive structure and logic, and in the second semester we will focus on language games, information and pragmatics. The modules will be four weeks long. During the first two weeks of a module, we will read and discuss original texts and supplementary criticism. During the second two weeks, we will read recent NLP papers and discuss how the authors of those works are building on philosophical insights into our conception of language—perhaps implicitly or unwittingly.

Content

The literature will be provided by the instructors on the class website.

Literature

The literature will be provided by the instructors on the class website.

Minor in Networking

Number Title

252-1411-00L Security of Wireless Networks

Abstract

Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.

Objective

After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.

Content


253-4640-00L Network Security

Abstract

This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data.
This course provides an in-depth study of network attack techniques and methods to defend against them.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0064-00L or 252-0111-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

This course provides an in-depth study of network attack techniques and methods to defend against them.

Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
(3) analysis and inference topics such as traffic monitoring and network forensics; and
(4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.
### Minor in Programming Languages and Software Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
<tr>
<td>Abstract</td>
<td>Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection.</td>
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<tr>
<td>Objective</td>
<td>After this course, students will:</td>
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<tr>
<td></td>
<td>Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.</td>
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<td>Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.</td>
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<td>Be able to learn new languages more rapidly.</td>
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<td>Be aware of many subtle problems of object-oriented programming and know how to avoid them.</td>
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<tr>
<td>Content</td>
<td>The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.</td>
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<td>The topics discussed in the course include among others:</td>
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<td></td>
<td>The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)</td>
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<td></td>
<td>The key problems of single and multiple inheritance and how different languages address them</td>
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<td>Generic type systems, in particular, Java generics, C# generics, and C++ templates</td>
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<td></td>
<td>The situations in which object-oriented programming does not provide encapsulation, and how to avoid them</td>
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<td></td>
<td>The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing</td>
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<td></td>
<td>How to maintain the consistency of data structures</td>
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<tr>
<td>Literature</td>
<td>Will be announced in the lecture.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience.</td>
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<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
</tr>
<tr>
<td>Abstract</td>
<td>Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.</td>
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<tr>
<td>Objective</td>
<td>Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.</td>
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<tr>
<td>Content</td>
<td>The course is split into 3 parts:</td>
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<td></td>
<td>Robustness in Deep Learning</td>
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<td></td>
<td>- Adversarial attacks and defenses on deep learning models.</td>
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<td></td>
<td>- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).</td>
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<td></td>
<td>- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).</td>
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<tr>
<td>Privacy of Machine Learning</td>
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<td></td>
<td>- Threat models (e.g., stealing data, poisoning, membership inference, etc.).</td>
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<td></td>
<td>- Attacking federated machine learning (across modalities such as vision, natural language and tabular).</td>
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<td></td>
<td>- Differential privacy for defending machine learning.</td>
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<td></td>
<td>- Enforcing regulations with guarantees (e.g., via provable data minimization).</td>
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<tr>
<td>Fairness of Machine Learning</td>
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<td></td>
<td>- Introduction to fairness (motivation, definitions).</td>
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<tr>
<td></td>
<td>- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).</td>
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<tr>
<td></td>
<td>- Enforcing group fairness with guarantees.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).</td>
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<tr>
<td></td>
<td>For solving assignments, some programming experience in Python is expected.</td>
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</tbody>
</table>
The first part of the lecture covers individual system aspects starting with tamperproof or tamper-resistant hardware in general over Advanced topics in parallel and high-performance computing.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

 Minor in Systems Software

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>W</td>
<td>7</td>
<td>2V+1U+2A</td>
<td>S. Capkun, S. Shinde</td>
</tr>
</tbody>
</table>

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

 Data Management Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-3845-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>W</td>
<td>8</td>
<td>3V+1U+3A</td>
<td>G. Alonso</td>
</tr>
</tbody>
</table>

Abstract
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place a special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature
The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

Prerequisites / notice
The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1264 of 2345
This course is about equipping students whose focus is systems with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers. By the end of the course, students should be able to seamlessly integrate basic concepts from formal methods into how they conceive, design, implement, reason about, and debug computer systems.

The goal is not to provide a comprehensive introduction to formal methods - this is well covered by other courses in the department. Instead, it is intended to provide students in computer systems (who may or may not have existing background knowledge of formal methods) with a basis for applying formal methods in their work.

This course does not assume prior knowledge of formal methods, and will start with a quick review of topics such static vs. dynamic reasoning, variants and invariants, program algebra and refinement, etc. However, it is strongly recommended that students have already taken one of the introductory formal methods course at ETH (or equivalents elsewhere) before taking this course - the emphasis is on reinforcing these concepts by applying them, not to teach them from scratch.

Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified sel4 microkernel will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).

### Minor in Theoretical Computer Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>A. Lapidoth</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.</td>
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<tr>
<td>Objective</td>
<td>The fundamentals of Information Theory including Shannon's source coding and channel coding theorems</td>
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<tr>
<td>Content</td>
<td>The entropy rate of a source. Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity</td>
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<tr>
<td>Literature</td>
<td>T.M. Cover and J. Thomas, Elements of Information Theory (second edition)</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>A. Steger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Las Vegas &amp; Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks</td>
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<tr>
<td>Objective</td>
<td>After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.</td>
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<tr>
<td>Content</td>
<td>Randomized Algorithms are algorithms that &quot;flip coins&quot; to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.</td>
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<tr>
<td>Lecture notes</td>
<td>Yes</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
<tr>
<td>Abstract</td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
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<tr>
<td>Objective</td>
<td>Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge arising from solving modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.</td>
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<tr>
<td>Content</td>
<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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<tr>
<td>Topics covered in the lecture include:</td>
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<td>Fundamentals:</td>
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<tr>
<td>What is data?</td>
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<td>Bayesian Learning</td>
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<td>Computational learning theory</td>
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<td>Supervised learning:</td>
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<tr>
<td>Ensembles: Bagging and Boosting</td>
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<tr>
<td>Max Margin methods</td>
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<tr>
<td>Neural networks</td>
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<tr>
<td>Unsupervised learning:</td>
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<tr>
<td>Dimensionality reduction techniques</td>
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<tr>
<td>Clustering</td>
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<tr>
<td>Mixture Models</td>
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<tr>
<td>Non-parametric density estimation</td>
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<tr>
<td>Learning Dynamical Systems...</td>
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<tr>
<td>Lecture notes</td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
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</tbody>
</table>
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning.

Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-1425-00L

Geometry: Combinatorics and Algorithms

8 credits

Abstract

Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

Objective

The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains.

Content

Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in Rd, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Lecture notes

yes

Literature


263-5300-00L

Guarantees for Machine Learning

Number of participants limited to 30.

W 7 credits

Abstract

This course is aimed at advanced master and doctoral students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- stability and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Taught competencies

Subject-specific Competencies: Concepts and Theories

Method-specific Competencies: Analytical Competencies, Problem-solving

Social Competencies: Cooperation, Communication, Teamwork

Personal Competencies: Critical Thinking, Creative Thinking

401-3054-14L

Probabilistic Methods in Combinatorics

6 credits

Abstract

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content

The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, concentration inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

Cooperation and Teamwork

No

Social Competencies

No

Personal Competencies

No

Data: 18.08.2022 12:39

Autumn Semester 2022

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Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvectors of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely. Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Literature


### Prerequisites

Solid background in linear algebra.

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Project Management</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td></td>
<td>Self-assertiveness and Self-reflection</td>
<td>Self-awareness and Self-management</td>
</tr>
</tbody>
</table>

### Notice

Former course title: Mathematical Optimization.

### Interfocus Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-0006-00L</td>
<td>Algorithms Lab</td>
<td>O</td>
<td>8</td>
<td>4P+3A</td>
<td>A. Steger, E. Welzl</td>
</tr>
</tbody>
</table>
Abstract

Students learn how to solve algorithmic problems given by a textual description (understanding problem setting, finding appropriate modeling, choosing suitable algorithms, and implementing them). Knowledge of basic algorithms and data structures is assumed; more advanced material and usage of standard libraries for combinatorial algorithms are introduced in tutorials.

Objective

The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, CGAL, and BGL).

Literature


<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>ECTS</th>
<th>Type</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-0009-00L</td>
<td>Information Security Lab</td>
<td>8</td>
<td>O</td>
<td>2V+1U+3P+1A K. Paterson, D. Basin, S. Capkun, D. Hofheinz, A. Perrig, S. Shinde</td>
</tr>
<tr>
<td></td>
<td>Only for master students!</td>
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</tbody>
</table>

Abstract

This InterFocus Course will provide a broad, hands-on introduction to Information Security, introducing adversarial thinking and security by design as key approaches to building secure systems.

Objective

This course will introduce key concepts from Information Security, both from attack and defence perspectives. Students will gain an appreciation of the complexity and challenge of building secure systems.

Content

The course is organised in two-week segments. In each segment, a new concept from Information Security will be introduced. The overall scope will be broad, including cryptography, protocol design, network security, system security.

Lecture notes

Will be made available during the semester.

Literature

Paul C. van Oorschot, Computer Security and the Internet: Tools and Jewels.
Dan Boneh and Victor Shoup, A Graduate Course in Applied Cryptography.

Prerequisites / notice

Ideally, students will have taken the D-INFK Bachelors course “Information Security” or an equivalent course at Bachelors level.

Elective Courses

Students can individually choose from the entire Master course offerings in the area of Computer Science (or a closely related field), from ETH Zurich, EPF Lausanne, the University of Zurich and - but only with the consent of the Director of Studies - from all other Swiss universities.

Number | Title                                      | ECTS | Type       | Lecturers          |
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>252-0293-00L</td>
<td>Wireless Networking and Mobile Computing</td>
<td>8</td>
<td>W</td>
<td>S. Mangold</td>
</tr>
</tbody>
</table>

Abstract

This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.

Objective

The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.

Content

Wireless Communication, Wi-Fi, Contact Tracing, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.

Chapters:

1 Introduction
2 Wireless Communication Basics
3 IEEE 802.11 Wireless LAN (Wi-Fi)
4 IEEE 802.15 Wireless PAN (ZigBee & Bluetooth)
5 Mobile Computing Algorithm Basics: Control and Game Theory
6 Visible Light Communication
7 Audio Communication
8 Cellular Networking Basics (LTE, 5G, Internet-of-Things)
9 Mobile Computing for Automated Medicine Delivery
10 Cognitive Radio, Delay Tolerant Networking, Radio Spectrum Sharing

Lecture notes

The course material will be made available by the lecturer.

Literature

1 The course webpage (look for Stefan Mangold's site)
2 The Java 802 protocol emulator "JEmula802" from https://bitbucket.org/lfield/jemula802

Prerequisites / notice

Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).
Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Customer Orientation</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

263-0600-00L  Research in Computer Science  W 5 credits  11A  Professors

Abstract
Independent project work under the supervision of a Computer Science Professor.

Objective
Independent project work under the supervision of a Computer Science Professor.

Prerequisites / notice
Only students who fulfill one of the following requirements are allowed to begin a research project:
- 1 lab (interfocus course) and 1 focus course
- 2 core focus courses
- 2 labs (interfocus courses)

A task description must be submitted to the Student Administration Office at the beginning of the work.

263-5053-00L  Technology Investing  W 2 credits  3S  A. Illic, C. Jurytko, A. Lidberg

Abstract
Technology has the potential to transform our society. But without the right team & funding, some break-throughs will never see the light of day. This seminar helps aspiring student/research entrepreneurs to understand how to fund their path from research into practice. The examples and cases will be primarily from software, AI, and other deep-tech ventures.

Objective
After attending this course, students will be able to:
- Explain the differences between VC and founder thinking
- Evaluate if a start-up is suited for venture capital (“VC readiness”)
- Evaluate founder friendliness of term sheets
- Determine funding needs & strategy for a start-up from research to first round
- Write and evaluate an investment memo

Content
The course is practically oriented and features guest speakers from leading venture capital firms and start-ups. The course embraces a unique perspective combining technology and investor thinking. The seminar is structured around five days with the following themes.

- The macro picture. Why does venture capital exist? What are major tech break-through areas and their disruptive potential? We also review the differences in the US and European perspective as well as developments towards more impact and diversity conscious funds.
- A peek into the mind of a VC. How to build a successful VC? Learn what key factors & processes required to build a successful venture capital company. This includes strategic decisions for investment thesis, structure of a fund, portfolio economics, valuation & ownership targets, cap table. In addition, we introduce the fundamentals of the investment process (including due diligence, term sheets, and deal memo) as well as portfolio management.
- The founder’s perspective. Why should you raise venture capital and how? Learn to evaluate the founder friendliness of terms, company approach, strategic decisions, negotiation and valuation.
- Fundraising types. Learn about different types of funding and their implications. This includes an overview of the Swiss ecosystem and a discussion of the different types (grants, equity, loans, SAFE, crowd, …). We also include a practical session on crypto technology for modern fund-raising using launchpads and tokenized shares.
- Tying it all together. The last day is focused on simulating an investment committee meeting where the groups present their deal memos and discuss with the audience.

263-5054-00L  Patenting Digital Innovations  W 1 credit  2S  A. Illic, B. Best

Abstract
In this seminar dedicated to digital innovations, we will bust the most stubborn myths around AI software patents such as “Software/AI isn’t patentable”, “AI patents are useless because you can’t figure out if they are infringed”, and many others. We will look at how AI and software start-ups can use patents to create a strong IP position in a scalable way.

Objective
After attending this course, students will be able to:
- Understand the basics of patenting in the digital space relevant for a global market
- Evaluate patenting opportunities with a more differentiated view on the topic
- Effectively use patents as a cost-effective part of a technology startup’s business plan
- Conduct patent searches, freedom-to-operate analysis and infringement analyses
- Write their first software/AI-related invention disclosure suitable for patenting
The course is focused on patenting digital innovations. It is designed for students with entrepreneurial interests that like to get a hands-on perspective on the topic of intellectual property strategies and patents.

The seminar includes presentations and practical group exercises to apply the acquired knowledge in practice. Entrepreneurs and leading IP experts are joining the seminar as guest speakers for discussion of real-life examples.

Topics that will be covered include:
- Best practices that any AI/software startups should know about IP and patents
- How investors evaluate a strong IP situation of a start-up
- How to efficiently monitor competitor patent activity and obtain "FTO"
- How to create an effective patent filing strategy that grows with the business
- How to efficiently create AI patents while not getting distracted from the founder’s core business

The course also contains a group work of a "FTO battle" where two teams compete in a freedom-to-operate analysis and individual work to write their first invention disclosure related to an AI or software topic.

227-2210-00L  Computer Architecture  8 credits  6G+1A  O. Mutlu

Abstract
Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective
We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

Lecture notes
See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture/

The video recordings of the lectures are expected to be made available after lectures.

See https://safari.ethz.ch/architecture for past examples.

We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

See https://safari.ethz.ch/architecture for past examples.

Prerequisites / notice

Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-INFK

see Science in Perspective: Language Courses ETH/UZH

Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-0800-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
The Master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective
To work independently and to produce a scientifically structured work under the supervision of a Computer Science Professor.

Content
Independent project work supervised by a Computer Science professor. Duration 6 months.

Prerequisites / notice
Supervisor must be a professor at D-INFK or affiliated, see https://inf.ethz.ch/people/faculty.html

Computer Science Master - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
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<td>Key for Hours</td>
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</tr>
<tr>
<td>V</td>
<td>lecture</td>
<td>P</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
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<tr>
<td>U</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
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ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Integrated Building Systems Master

### Main Courses

#### Fundamental Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1633-00L</td>
<td>Energy Conversion</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>I. Karin, G. Sansavini</td>
</tr>
</tbody>
</table>

**Abstract**

This course is intended for students outside of D-MAVT.

**Objective**

This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.

**Content**

1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

**Prerequisites**

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.

**Literature**


Lecture slides and supplementary documentation will be available online.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0203-00L</td>
<td>Mathematics</td>
<td>W</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>C. Busch</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an introduction to the following subjects:

- Linear algebra (systems of linear equations, matrices, eigenvectors), calculus, multivariable calculus, differential equations.

**Objective**

Basic mathematical knowledge for engineers. Mathematics as a tool to solve engineering problems.

**Content**

This course gives an introduction to the following subjects:

- Linear algebra (systems of linear equations, matrices, eigenvectors), calculus, multivariable calculus, differential equations.

**Literature**

- Tom M. Apostol, Calculus, Volume 1, One-Variable Calculus with an Introduction to Linear Algebra, 2nd Edition, Wiley
- Ulrich L. Rohde, Introduction to differential calculus : Systematic studies with engineering applications for beginners, Wiley.
- Ulrich L. Rohde, Introduction to integral calculus : Systematic studies with engineering applications for beginners, Wiley.

A list will be handed out in the lecture.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>066-0427-00L</td>
<td>Design and Building Process MIBS</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

"Design and Building Process MIBS" is a brief manual for prospective architects and engineers covering the competencies and responsibilities of all involved parties through the design and building process. Lectures on twelve compact aspects gaining importance in a increasingly specialised, complex and international surrounding.
Participants will come to understand how they can best navigate the design and building process, especially in relation to understanding their profession, gaining a thorough knowledge of rules and regulations, as well as understanding how involved parties’ minds work. They will also have the opportunity to investigate ways in which they can relate to, understand, and best respond to their clients’ wants and needs. Finally, course participants will come to appreciate the various tools and instruments, which are available to them when implementing their projects. The course will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship.

“Design and Building Process MIBS” is a brief manual for prospective architects and engineers covering the competencies and the responsibilities of involved parties through the design and building process. Twelve compact aspects regarding the establishe building culture are gaining importance in an increasingly specialised, complex and international surrounding. Lectures on the topics of profession, service model, organisation, project, design quality, coordination, costing, tendering and construction management, contracts and agreements, life cycle, real estate market, and getting started will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship. The course introduces the key figures, depicts the criteria of the project and highlights the provided services of the consultants. In addition to discussing the basics, the terminologies and the tendencies, the lecture units will refer to the studios as well as the practice: Teaching-based case studies will compliment and deepen the understanding of the twelve selected aspects. The course is presented as a moderated seminar to allow students the opportunity for individual input: active collaboration between the students and their tutor therefore required.

The recordings of the lectures are available on the MAP under the link https://map.arch.ethz.ch (book symbol at the top right). Further information and documents for the lecture can be found on the homepage of IRL/STL (https://map.arch.ethz.ch).

ZoomLink: https://ethz.zoom.us/j/66588100789

101-0527-10L Materials and Constructions

Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sources, properties and performance, building envelope integration and detailing, sustainable building construction

Materials for the building envelope:
- Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
- Insulating materials (bio-based conventional)
- Air barrier, vapour barrier and sealants
- Interior finishing

Assessment of materials and components behaviour and performance

Solutions for energy retrofitting of (historical) buildings

Aspects of sustainability and durability

ICTA Pool - information event on the courses offered at the institute ICTA: Wednesday 8th September 2021, 10-11 h, ONLINE.

ITA Pool - information event on the courses offered at the institute ITA: Wednesday 8th September 2021, 10-11 h, ONLINE.

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ITA Pool - information event on the courses offered at the institute ITA: Wednesday 8th September 2021, 10-11 h, ONLINE.
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and critical thinking skills.

**151-8011-00L Building Physics: Theory and Applications**

*Enrolment after agreement with the lecturer only.*

**Objectives**
- Principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

**Content**
- Principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

**Lecture notes**
Handouts, supporting material and exercises are provided online via Moodle.

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**363-0389-00L Technology and Innovation Management**

**Objective**
This course intends to enable all students to:

- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes.
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes.
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes.

**Content**
This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, guest speakers, simulations and group work.

**Lecture notes**
Slides will be available on the Moodle page.

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**363-0503-00L Principles of Microeconomics**

**Objective**
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

**Content**
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

**Topics covered by the course are:**
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

**Lecture notes**
Lecture notes, exercises and reference material can be downloaded from Moodle.
**Literature**

The book can also be used for the course ‘Principles of Macroeconomics’ (Sturm)

For students taking only the course ‘Principles of Microeconomics’ there is a shorter version of the same book:

**Complementary:**

**GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.**

**Taught competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

**Abstract**

Fundamentals, Applications and Project works in the area of CFD in buildings.

**Objective**

I- Understanding:
- Basic principles of fluid flow & heat transfer
- Basic concepts of CFD
- Validation and verification, practical guidelines

II- Application and project works of CFD in buildings. Use of the CFD software www.transat-cfd.com only, which is installed in the computer room of the Archi. Department.

Students will have two projects:

1- Group projects: Beginning of Nov. Projects will be assigned by the tutors to the students organized in groups of 2. Projects will include canonical problems in two dimensions essentially. A report is to be handed out end of Nov.

2- Individual Projects: 2nd week of Nov. to Christmas. These are individual projects, chosen by students from the list of items below.

NOTE:
Students enrolled in the "Integrated Design Project" course can use their Individual Project (this class) for their IDP project, provided (1) they attend this course (CFD in Buildings) and use the CFD code TransAT to benefit the support of the tutors.

**Content**

I. Fundamentals
- Basic principles of fluid flow & heat transfer
- Laminar versus turbulent flow
- Forced vs. natural convection
- Basic concepts of CFD (Discretization, schemes, solvers, etc.)
- Turbulence modelling
- Near-wall treatment
- Validation and verification, practical guidelines

II. Application of CFD for real problems including (Projects):

1. Wind – Urban Scale: students would use the building shape to determine locations for wind inlets and outlets based on façade pressures
2. Wind – Cross-ventilation: using the interior shape of a building with inlets and outlets to determine flow rates
3. Stack effect: on a windless day with people in the building, how much airflow would be anticipated airflow rate given inlets and outlets
4. Wind & heat removal: Given inlets and outlets with people in the building, how much heat is removed from the building
5. Solar chimney: given a building with a chimney, how much extra airflow is created if the chimney is solar (absorbs radiation) vs. typical (not designed to absorb radiation)
6. Plant/vegetation effects: Given a building with a courtyard, how much is cross-ventilation affected by including plants vs. not having plants or how will the plants affect stack venting.
7. Air pollution and contaminant dispersion

**Application of CFD in Buildings**

W 3 credits 3V D. Lakehal

Limited number of participants.
Enrolment is only possible in agreement with the chair.

**Lecture notes**

Material (pdf files) will be sent to the students before the start of the course.
Main reference for fluid mechanics:
J.H. Spurk, Fluid Mechanics, Springer

Main reference for CFD: Ferziger and Peric, Computational Methods for Fluid Mechanics, Springer

Main Wiki reference:

Other useful papers:

### Taught competencies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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### 151-8007-00L Urban Physics

**Abstract**
Urban physics: wind, wind comfort, pollutant dispersion, natural ventilation, driving rain, heat islands, climate change and weather conditions, urban acoustics and energy use in the urban context.

**Objective**
- Basic knowledge of the global climate and the local microclimate around buildings
- Impact of urban environment on wind, ventilation, rain, pollutants, acoustics and energy, and their relation to comfort, durability, air quality and energy demand
- Application of urban physics concepts in urban design

**Content**
- Climate Change. The Global Picture: global energy balance, global climate models, the IPCC process. Towards regional climate scenarios; role of spatial resolution, overview of approaches, hydrostatic RCMs, cloud-resolving RCMs
- Urban micro climate and comfort: urban heat island effect, wind flow and radiation in the built environment, convective heat transport modelling, heat balance and ventilation of urban spaces - impact of morphology, outdoor wind comfort, outdoor thermal comfort,
- Urban energy and urban design. Energy performance of building quarters and cities, decentralized urban energy production and storage technologies, district heating networks, optimization of energy consumption at district level, effect of the micro climate, urban heat islands, and climate change on the energy performance of buildings and building blocks.
- Wind driving rain (WDR): WDR phenomena, WDR experimental and modeling, wind blocking effect, applications and moisture durability
- Pollutant dispersion, pollutant cycle: emission, transport and deposition, air quality
- Urban acoustics. noise propagation through the urban environment, meteorological effects, urban acoustic modeling, noise reduction measures, urban vegetation
- Practical exercise on climatic data collection and analyze

**Lecture notes**
The course lectures and material are provided online via Moodle.

**Prerequisites / notice**
The course is open to MIBS Master students. For MiBS Master students 151-8011-ooL Building Physics Theory & Application is a pre-requisite for this course or instructor permission. For others no prior knowledge is required.

### 066-0421-00L Building Systems I

**Abstract**
Building Systems I gives an overview of fundamentals and concepts relevant for the design of building systems.

**Objective**
The course has the following learning objectives:
- Knowledge of the fundamentals, principles and technologies for building heating, cooling, ventilation and electricity supply.
- Knowledge of the integration and interdependencies of building systems and building structure, construction and aesthetics
- Ability to estimate relevant quantities and qualities for heating/cooling/ventilation/electricity of buildings and the related supply systems
- Ability to evaluate and choose an approach for sustainable heating/cooling/ventilation/electricity, the system and its components
- Synthesis in own integrated design projects

**Content**
1. Comfort & Environment
2. Heating / cooling concepts and demand
3. Natural / mechanical ventilation concepts and demand
4. Solar generation / electricity storage and demand
5. Information & Communication Technologies

### 101-0608-00L Design-Integrated Life Cycle Assessment

**Abstract**
Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process.

The aim of this course is to apply LCA during the design of buildings by means of a digital, parametric tool. The necessary fundamentals of the LCA method will be taught following a lecture on demands approach.

**Objective**
The course will follow two main objectives and a third optional objective, depending on the design projects the students’ choose. At the end of the course, the students will:
1. Know the methodology of LCA
2. Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation
Content
The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand
The first six individual courses will follow the "lectures on demand" approach. Small "hands-on" exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:
1) LCA basic introduction
2) System boundaries, functional unit, end of life
3) Carbon budget and LCA benchmarks
4) BIM-LCA, available calculation tools and databases
5) Integrated analysis of environmental and cost assessment
6) Bio-based carbon storage

Part II: Project-based learning
In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:
1) Introduction to Rhinoceros 6 and 7
2) Introduction to grasshopper
3) Integrated assessment tools (ladybug tools)
4) Introduction to in-house grasshopper plugin for LCA analysis

Lecture notes
As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

Prerequisites / notice
Prerequisite: Sustainable construction (101-0577-00L). Otherwise a special permission by the lecturer is required.

The lecture series will be conducted in English and is aimed at students of master's programs, particularly the departments ARCH, BAUG, ITET, MAVT, MTEC and UWIS.

No lecture will be given during Seminar week.

151-0209-00L Renewable Energy Technologies W 4 credits 3G A. Steinfeld, E. I. M. Casati
Abstract Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.
Objective Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.
Lecture notes Lecture Notes containing copies of the presented slides.
Prerequisites / notice Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

101-0123-00L Structural Design W 3 credits 2G F. Bertagna, D. Tanadini, P. Block, P. Ohlbrock, J. Schwartz
Abstract The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects.
Objective After successfully completing this course the students will be able to:
1. Critically question structural design concepts of historical and contemporary references
2. Understand different construction technologies and have an awareness of their potential for structural design
3. Design an appropriate structural system for a given design task taking into account architectural considerations

151-0909-00L Chemistry W 4 credits 2V+2U D. J. Norris
Abstract This is a general chemistry course aimed at first-year bachelor students in the Department of Mechanical and Process Engineering.
## Specialised Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0100-00L</td>
<td>Fluid Dynamics II</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>P. Jenny</td>
</tr>
</tbody>
</table>

**Abstract**
- Two-dimensional irrotational (potential) flows: stream function and potential, singularity method. Unsteady flow, aerodynamic concepts.
- Vorticity dynamics: vorticity and circulation, vorticity equation, vortex theorems of Helmholtz and Kelvin.
- Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Meyer expansion, viscous effects.

**Objective**
Expand basic knowledge of fluid dynamics.

**Content**
- Concepts, phenomena and quantitative description of irrotational (potential), rotational, and one-dimensional compressible flows.
- Two-dimensional irrotational (potential) flows: stream function and potential, complex notation, singularity method, unsteady flow, aerodynamic concepts.
- Vorticity dynamics: vorticity and circulation, vorticity equation, vortex theorems of Helmholtz and Kelvin.
- Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Meyer expansion, viscous effects.

**Lecture notes**
Lecture notes are available (in German). (See also info on literature below.)

**Prerequisites / notice**
Relevant chapters (corresponding to lecture notes) from the textbook


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<tr>
<td>401-0647-00L</td>
<td>Introduction to Mathematical Optimization</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>D. Adjiashvili</td>
</tr>
</tbody>
</table>

**Abstract**
- Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.
- The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.
- Topics covered in this course include:
  - Linear programming (simplex method, duality theory, shadow prices, ...).
  - Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
  - Modelling with mathematical optimization: applications of mathematical programming in engineering.

**Prerequisites / notice**
Analysis I/II, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas

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<tr>
<td>227-0477-00L</td>
<td>Acoustics I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>K. Heutschi</td>
</tr>
</tbody>
</table>

**Abstract**
- Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.
- Fundamentals of acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

**Lecture notes**
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

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<td>101-0577-00L</td>
<td>An Introduction to Sustainable Development in the Built Environment</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Habert, D. Kaushal</td>
</tr>
</tbody>
</table>

**Abstract**
- In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change.
- In 2016, other political bodies made these changes more difficult to predict.
- What does it mean for the built environment?
- This course provides an introduction to the notion of sustainable development when applied to our built environment
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environment aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

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- Overview on the current understanding and definition of sustainable development

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- Synthesis: Transition to sustainable development

All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

The course provides the necessary knowledge to develop models supporting the solution of given planning problems. Interim lab session take place regularly to guide and support students with the applied part of the course.

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis.

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

Students - assess the limits and the potential of corporate sustainability for sustainable development
- develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method.
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams with different output formats (tv-style debate, consultancy pitch, technology model walk-through, campaign video)
In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share his insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

Presentation slides will be made available on moodle prior to lectures. Literature recommendations will be distributed during the lecture.

Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Lecture notes and slides are available online and will be distributed if desired. Literature recommendations and references are included in the lecture notes.

**402-0809-01L**

**Introduction to Computational Physics** (for Civil Engineers)

| W | 4 credits | 2V+1U | A. Adelmann |

**Abstract**

This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

**Objective**

Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**

Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Lecture notes and slides are available online and will be distributed if desired. Literature recommendations and references are included in the lecture notes.

**101-0187-00L**

**Structural Reliability and Risk Analysis**

| W | 3 credits | 2G | S. Marelli |

**Abstract**

Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

**Objective**

The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

**Content**

Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro-codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FORM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

**Literature**


S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.
Will be identified based on the chosen topic.

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems. This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policymakers.

This course will help you answer these questions. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax versus permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. A final chapter, we consider international environmental problems and in particular climate change and climate policy.


This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
### Workshop on Sustainable Building Certification

**101-0587-00L**

**Title:** Workshop on Sustainable Building Certification

**Type:** W 3 credits 2G

**Does not take place this semester.**

**Number of participants limited to 25**

**Abstract:** Building labels are used to certify buildings and neighbourhoods in terms of sustainability. Many different labels have been developed and can be used in Switzerland (LEED, DGNB, SNBS, Minergie, 2000-Watt-Sites). In this course, the differences between the certification labels and its application on 3 emblematic case study buildings will be discussed.

**Objective:** After this course, the students are able to understand and use the different certification labels. They have a clear view of what the labels take into consideration and what they don't.

**Content:** Three buildings case study will be presented.

- Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

- After this overall general presentation and in order to have a closer look to specific aspects of sustainability, students will work in groups and assess during one or two weeks this specific criteria on one of the case studies presented before. This practical hands-on the label will end with a presentation and a discussion where we will highlight differences between the labels.

- This alternation of working session on one specific criteria for one specific building followed by a group presentation and discussion to compare labels is repeated for the different focus point (operation energy, mobility, daylight, indoor air quality).

**Lecture notes:** The slides from the presentations will be made available.

**Literature:** All documents for certification labels as well as detail plans of the buildings will be available for the students.

### Informatics

**252-0839-00L**

**Title:** Informatics

**Type:** W 2 credits 2G

**L. E. Fässler, M. Dahinden**

**Abstract:** Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists and tables and with relational databases, introduction to programming.

**Objective:** The students learn to

- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

**Content:**

1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python

**Lecture notes:** All materials for the lecture are available at www.evim.ethz.ch

**Prerequisites / notice:** This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

### Project Management for Construction Projects

**101-0007-00L**

**Title:** Project Management for Construction Projects

**Type:** W 4 credits 3S

**J. J. Hoffman**

**Abstract:** This course is designed to lay down the foundation of the different concepts, techniques, and tools for successful project management of construction projects.
The goal is that at the end of this course students should have a good understanding of the different project management knowledge areas, the phases required for successful project management, and the role of a project manager. To demonstrate this, students will work in groups in different case studies to apply the concepts, tools and techniques presented in the class.

Two 3 to 4 hours sessions towards the end of the lecture series will introduce a practical project to allow the teams to demonstrate the tools and techniques learned during the semester. The course will have a final quiz that will be graded.

The main content of the course is summarized in the following topics:

- Project and organization structures
- Project scheduling
- Resource management
- Project estimating
- Project financing
- Risk management
- Project Reporting
- Interpersonal skills

Relevant readings will be recommended throughout the course (and made available to the students via Moodle).

The students will be randomly assigned to teams. Students will be graded as a team based on the final Project report and the in-class oral presentation of the Project Proposal as well as a final exam (50% exam and 50% project report and presentation). Homework will not be graded but your final report and presentation will consist mostly of your homework assignments consolidated and put in a report and presentation format.

851-0589-00L Technology and Innovation for Development W 3 credits 2V P. Aerni

Abstract Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

Objective
- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies.

The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes Reader with issue-specific articles. E-version is partly available on Moodle


Aerni, P. (2021b) ‘Decentralized economic ecosystems in Switzerland and their contribution to inclusive and sustainable change’. Sustainability 13(8), 4181


Aerni, P. 2016a. Coping with Migration-Induced Urban Growth: Addressing the Blind Spot of UN Habitat. Sustainability 8(800)


Romer, P. 2020. What It Takes To Be a Leader in Both Basic Science and Technological Progress. Statement for House Budget Committee Hearing on Federal R&D (https://paulromer.net/statement-for-house-budget-committee/)


The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester. The class will be taught in English.

Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

### 376-1177-00L Human Factors I

| Abstract | Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.
| Objective | The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.
| Content | - Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks
| Literature | - Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

### 103-0569-00L European Aspects of Spatial Development

| Abstract | Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.
| Objective | Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making
| Content | - European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives
| Lecture notes | The documents for the lecture will be provided at the moodle.
The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students. 

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Method-specific Competencies
- Analytical Competencies
- Decision-making

Obligatory literature:

Recommended literature:

Planning models:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

Planning systems in Europe:

Prerequisites / notice
Only for master students, otherwise a special permission by the lecturer is required.

Taugted competencies

Subjects-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making

Social Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

851-0252-08L Evidence-Based Design: Methods and Tools for Evaluating Architectural Design
Number of participants limited to 40

W 3 credits 2S M. Gath Morad, C. Hölscher, L. Narvaez Zertuche, C. Veddeler

Particularly suitable for students of D-ARCH

Abstract
Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement range of methods on a sample project. The course is tailored for architecture design students.

Objective
The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

252-0834-00L Information Systems for Engineers

W 4 credits 2V+1U G. Fourny

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes
13. Outlook

Literature

- Lecture material (slides).
   (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logics

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

052-0707-00L

Urban Design III

Students are introduced to a narrative of 'Urban Stories' through a series of three tools driven by social, governance, and environmental transformations in today's urbanization processes. Each lecture explores one city's spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.

How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.
Content

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

Abstract

The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them.

Objective

The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course, students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance-optimized technical products. The exercises are MATLAB based.

Content

1. Optimization modeling and theory
2. Unconstrained optimization methods
3. Constrained optimization methods - linear and non-linear
4. Direct search methods
5. Stochastic and evolutionary search methods
6. Multi-objective optimization

Lecture notes available on Moodle

151-3209-00L Engineering Design Optimization W 4 credits 4G K. Shea, T. Stankovic

Number of participants limited to 60.

Content

1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Constrained optimization methods
3. Direct search methods
4. Multi-objective optimization

Literature

Suggested Reading:

Prequisites / notice

Familiarity with MATLAB and / or Python is advised.
This course teaches approaches and methods to identify, assess and manage environmental and societal aspects in organisations, such as ISO 14001 or the ecobalance of organisations, and how such approaches fit into a management system.

Students will learn to:
- describe key sustainability problems of the current economic system and measuring units;
- describe the management system of an organisation and how to develop a sustainability orientation;
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance);
- explain the pros and cons of single score environmental assessment methods;
- apply life cycle costing;
- interpret stakeholder relations of an organisation;
- (if time allows) describe sustainable supply chain management and stakeholder management.

The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SAB8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation (The concept of 'Continuous Improvement');
- life cycle costing;
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts;
- single score env. assessment methods (Swiss ecopoints);
- stakeholder management and sustainability oriented communication;
- an intro into sustainability issues of supply chain management.

Students will get small exercises related to course issues.

- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SAB8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation (The concept of 'Continuous Improvement');
- Life Cycle Costing, Life Cycle Management;
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts;
- single score env. assessment methods (Swiss ecopoints);
- stakeholder management and sustainability oriented communication;
- an intro into sustainability issues of supply chain management.

Students will get small exercises related to course issues.
### Prerequisites / notice
No prerequisites. Programme is open to Bachelor and Masters from all ETH Departments. All students must apply through a competitive application process at www.ethz.ch/ethweek. Participation is subject to successful selection through this competitive process.

### Taught competencies

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<th>Method-specific Competencies</th>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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### 051-0911-22L Seminar Week Autumn Semester 2022

- **W 2 credits 3A Lecturers**
- **Abstract**
The seminar week is obligatory for students of all semesters. There are many and varied study contents. The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

### 052-0639-22L Climate Responsive Architecture with Hive

- **W 1 credit 2G A. Schlüter, E. Borkowski**
- **Abstract**
This Online course provides an introduction to climate-responsive design using the Hive tool and how to apply it in early building design stages. Hive allows architecture and building science students to understand the relation between architectural design, climate, comfort and energy. Hive is a plugin for the 3D modeling environment Rhino and its visual programming interface Grasshopper.

- **Objective**
  - • Recall general principles of climate responsive design and examples of it.
  - • Utilize 3D building geometries to conduct simplified energy demand and supply simulations.
  - • Observe relevant physical principles and interactions between climate, energy and geometry.
  - • Implement passive and active concepts for Climate Responsive Design.
  - • Apply Hive for building design analysis and integrate it into own designs or in design courses.
  - • Identify and harness synergies and trade-offs between climate, energy and architectural design aspects.

- **Content**
The course can be frequented individually, or as a prerequisite for other courses such as the master course Climate and Energy Systems 3 or architectural design studios.
  1. Course overview.
  2. Introduction to climate responsive design.
  3. Introduction to Rhino, Grasshopper and Hive.
  4. Early solar analyses.
  7. Real-world Applications and Examples.

This is a blended-learning self-paced ONLINE COURSE that can be started at any time.

- **Prerequisites / notice**
  A working Rhino 6 or 7 license is necessary.

### 053-0607-22L Computational Methods of Energy- and Climate Design
As of FS23, this course will be offered in spring semesters only.

- **Abstract**
The course ‘Energy- and Climate Systems III’ introduces computational design and analysis methods and tools for climate responsive architectural design. Exercises throughout the semester allow applying new concepts learnt in exemplary architectural design tasks.

- **Objective**
By the end of this course, students will be able to:
  - • compare and assess passive and active design strategies for bioclimatic buildings
  - • analyze environmental site characteristics for its climate and (solar) energy potentials
  - • apply computational simulation tools to support performance-driven designs
  - • translate design ideas into parametric models and into optimization problems
  - • synthesize learnt content of the course in exemplary architectural design tasks, serving as a basis for the students’ future design studios and projects

- **Content**
  1. Concepts of climate responsive design
  2. Computational analysis methods
     - • Climate and site analysis
     - • Daylight, airflow and energy simulations
     - • Energy supply systems optimization models (energy hub)
  3. Computational methods for performance driven design
     - • Parametric design
     - • Sensitivity and uncertainty analysis
     - • Single and multi-objective optimization
  4. Exercises and walkthroughs
  5. Invited expert speakers and panel discussion
Students learn to use industrial robots such as the Universal Robot UR5 and understand basic principles of robotic control. At the end of the course, the subject of the course is robotic fabrication in architecture. Through exercises, basic skills such as robotic control are being taught and practiced. The course teaches how to develop a simple fabrication and material aware digital design process linked to a robotic fabrication procedure.

Requirements and Recommendations:
- MSc Arch: Successfully completed the online blended learning course 'Climate responsive architecture with Hive' beforehand (Requirement)
- Successful participation in the course 'Energie- und Klimasysteme I + II' (Recommendation)
- MSc MIBS / Eng: Successfully completed the online blended learning course 'Climate responsive architecture with Hive' beforehand. (Recommendation)
- Successful participation in the course 'Building Systems'. (Recommendation)

All students need to be capable of working with 'Rhinoceros 3D' & 'Grashopper' on 'Windows' or willing to acquire the necessary skills before or during the course.

**063-0611-22L The Digital in Architecture II**

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<td>Lecture 03 – Public Space</td>
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<td>Lecture 05 – Climate Change</td>
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<td>Lecture 06 – Technology</td>
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<td>Lecture 07 – Tourism</td>
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<td>Lecture 10 – Participation</td>
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<td>Lecture 11 – Architectural Agency</td>
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**Abstract**
Subject of the course is robotic fabrication in architecture. Through exercises, basic skills such as robotic control are being taught and practiced. The course teaches how to develop a simple fabrication and material aware digital design process linked to a robotic fabrication procedure.

**Objective**
Students learn to use industrial robots such as the Universal Robot UR5 and understand basic principles of robotic control. At the end of the course, students are able to translate simple design ideas into robotic fabrication processes, which they can run independently. Furthermore, students deepen their skills in Python and Grasshopper.

**Prerequisites / notice**
ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h: Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

**063-0805-22L History and Theory in Architecture IX**

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<th>Lecture</th>
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**Abstract**
This course offers a brief introduction to contemporary urban problems and challenges. Based on a thematic approach, the course explores how these issues pose a challenge to the fields of architecture, urban design and planning.

**Objective**
This course aims to offer a survey of the history and current state of urban theory for students of urban design and architecture. It is a somewhat commonplace to say that we live in an 'urban age': cities are the most common habitat for the inhabitants of the world, today. Moreover, while more than half the global population lives in cities according to the reports of the UN, it is expected that within the next few decades this number will increase to two-thirds. This 'urban' condition, however, cannot be generalized. Within the term 'city' a broad range of different urban conditions are taken together: from metropolises to suburban neighborhoods, and from shrinking (old industrial) cities to the new cities that prosper under the conditions of globalization. It also generalizes too much with regard to the urban condition within cities in the so-called Global North as compared to the Global South. In other words: the urban condition is as diverse as there are cities. However, it is also true that it is precisely in the cities that the challenges of our time are most apparent: globalization, gentrification, poverty, climate change. These topics call for a response.

The development of cities forms the topic of discussion, not only within the fields of architecture, urban design, spatial planning, but also among politicians, economists, sociologists, philosophers, citizens and activists. The urban realm and reality has provoked them to think and write about its form and functioning, appearance and structure, to protest against particular issues, and to take initiatives to direct the development in a different direction. Designers and planners reflect on the urban developments as well, sometimes in participating in the development themselves, sometimes from the sideline.

This course consists of weekly, one-hour lectures that address one particular topic at a time. In each lecture, this theme is investigated through different texts and case-studies that highlight crucial moments in the history and developments of cities. At the same time, the case studies will be structured so as to bridge between urban theories and concrete urban situations, design reflections and political ambitions. This will help convey to students the historical pedigree of current discourses on cities, whether simultaneously gain insight the role of designers in respect to the chosen topic. Students will prepare the meetings by reading fragments from core texts on the forehand.

The course is finalized through the writing of an essay, wherein the student is challenged to question how architectural agency can address (a) contemporary urban issue(s).
For this course, each week students will read fragments from key readings on the topics addressed. The readings will be made available via the website of the course prior to HS2022.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methodspecific Competencies</th>
<th>Social Competencies</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td></td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Media and Digital Technologies</td>
<td>Cooperation and Teamwork</td>
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</tbody>
</table>

**052-0731-22L** Housing Issues and Challenges in the Global South: Contributions of Architecture

**Abstract**

Can architecture, urban design and planning contribute to make housing and cities more equitable and inclusive? Answers to this question will be provided by socially engaged architects from Europe, Asia and Latin America through the presentation of concrete actions and projects.

**Objective**

The course aims at raising awareness about the multi-faceted manifestations and consequences of neo-liberal housing and urban policies. After a general introduction to the causes and consequences of the current global housing and urbanisation challenges, the students will learn through concrete examples that architects, planners and urban designers can make a difference. Socially engaged architects, designers and planners from Europe, Asia and Latin America will present actions and projects that contributed to make human settlements more inclusive, liveable and sustainable.

**Content**

The course will focus on the following topics:

- Global housing and urban challenges: an introduction
- From planning to actions against the commodification of public spaces in Vienna
- Countering the financialization of the city of Berlin
- Un-gating the city: the case of Bogota, Colombia
- Creating public space for popular culture in Barranquilla, Colombia
- Designing lights and sites of publicness in Mali
- Architectural activism and the re-emergence of housing cooperatives in Spain
- Enhancing social inclusion through participatory urban design in Milano, Italy
- Urban environmental activism, architecture and housing cooperatives in Switzerland
- Learning from vernacular building practices in India and Latin America
- Rebuilding housing and communities after conflicts and disasters
- Architecture for reconciliation and peace building in post-conflict settings

**Lecture notes**

A course overview including lecture summaries is made available to inscribed students prior the start of the semester.

**Literature**

A bibliography will be made available to inscribed students prior the start of the semester.

**151-0221-00L** Introduction to Modeling and Optimization of Sustainable Energy Systems

**Abstract**

This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

**Objective**

At the end of this course, students will be able to:

- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course "Introduction to Modeling and Optimization of Sustainable Energy Systems", the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

**Content**

The global energy transition: Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

**Lecture notes**

Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

**Project Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>066-0425-00L</td>
<td>Integrated Design MIBS ■</td>
<td>O</td>
<td>6</td>
<td>3V+3U</td>
<td>A. Schlüter</td>
</tr>
</tbody>
</table>

**Abstract**

During the integrated design studio students work on a selected integrated architectural / urban design project, considering both energy and climate systems (HVAC) as well architectural and urban design in a specific site context. The objective is to follow an integrated design process to achieve synergetic solutions.

**Objective**

The integrated design studio enables students to identify site specific energy demand and potentials, develop integrated energy and climate systems on both the urban and building scale and evaluate their interactions and impact on building design and operation.

**Content**

During the studio students will work in groups on a contemporary integrated design project (urban and / or building scale) executing an integrated design process from the analysis of site potentials, the identification of demands, the development of an urban scale energy concept and a matching building energy- and HVAC-systems concept. Input lectures from academics and professionals will highlight specific topics relevant to the task. The projects will be presented by the student groups and discussed with internal and external reviewers at midterm and at the final presentations.

**Lecture notes**

Skripts are specific to the design task and distributed at the beginning of the course.
Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>066-0431-00L</td>
<td>Semester Project MIBS</td>
<td>O</td>
<td>6</td>
<td>13A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract: The semester project focuses on solving specific research questions in the field of integrated building systems.

Objective: The semester project is designed to train students in solving specific research questions in the field of integrated building systems. The goal is to apply acquired knowledge which is gained throughout the first year of the master's program. The semester project is advised by a professor who is affiliated with one of the partner departments of the Master program "Integrated building systems".

Content: The semester project is designed to train students in solving specific research questions in the field of integrated building systems. The goal is to apply acquired knowledge which is gained throughout the first year of the master's program. The semester project is advised by a professor who is affiliated with one of the partner departments of the Master program "Integrated building systems".

Science in Perspective

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0801-00L</td>
<td>Global History of Urban Design I</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>T. Avermaete</td>
</tr>
</tbody>
</table>

Abstract: This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

Objective: The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.

Content: In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

- 01. The History and Theory of the City as Project
- 02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
- 03: The Idea of the Polis: Rome, Greece and Beyond
- 04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
- 05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
- 06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
- 07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
- 09: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
- 101: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
- 11: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

Lecture notes: Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

Literature: There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

Prerequisites / notice: A list of further recommended literature will be found within each chapter of the reader (Skript).

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

851-0609-06L Governing the Energy Transition Does not take place this semester. Primarily suited for Master and PhD level.

Abstract: This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.

Objective:
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions
- To gain knowledge on the role of policy and politics in energy transitions

Content: Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary.

This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

Lecture notes: Slides and reading material will be made available via moodle.ethz.ch (only for registered students).

Literature: A reading list will be provided via moodle.ethz.ch at the beginning of the semester.
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

Open- and User Innovation
W 3 credits 2G S. Häfliger, S. Spaeeth

Not for students belonging to D-MTEC!

Abstract
The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.

Objective
The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active class participation is required.

Content
This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

Lecture notes
The slides of the lectures are made available and updated continuously through the SMI website:

Literature
Relevant literature for the course includes slides and reading assignments. Papers will be made available through a corresponding Moodle group.

International Environmental Politics
W 3 credits 2V T. Bernauer

Particularly suitable for students of D-ITET, D-USYS

Abstract
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

Objective
The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Content
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Reading materials and slides will be available via Moodle.

Prerequisites / notice
This course will take place on campus (ETH Main Building, HF F.3).

The course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Sustainable Development - Bridging Art and Science
W 3 credits 2G S. Patel, J. Neve

Particularly suitable for students of D-ITET, D-USYS

Abstract
In this course students deepen their knowledge about global development and sustainability issues. We will show five movies each of them linked to one of the five P's (Planet, People, Prosperity, Peace and Partnerships) reflecting the topics of the 2030 Agenda. Afterwards the movie will be critically discussed with researchers and relevant stakeholders from the broader society.

Objective
- Students get a broad understanding of some of the most important issues and discussions related to sustainable development.
- Students get exposed to diverse realities of young people in developing countries.
- Students can critically reflect upon the information that is presented to them in the movies and relate it to the broader discussions around sustainable development.
- Students reflect on issues concerning communicating research and the realities of low-income settings to a wider public.

Content
The aim of the course is to deepen student’s knowledge about global issues and to inspire them to reflect critically upon complex topics, which are related to the broader discourse on sustainable development. In each class, we show a documentary film, which is linked to one of the five critical areas of the 2030 Agenda (Planet, People, Prosperity, Peace and Partnerships), putting specific focus on realities in developing countries. Following the movie screenings, we will discuss the topic of the film in the light of sustainable development with an expert from academia and/or a practitioner from the field of development cooperation. In preparation for each class, the students read an academic paper, which will also be considered in the discussion. The idea of "Bridging Art and Science" is to expose an interdisciplinary group of students to artistic and scientific perspectives alike and to challenge them to deal with bias and polarization, and the role that the media and films play in that regard. The participants of the course will be given the chance to embrace the complexity of sustainable global development.

Human-Computer Interaction: Cognition and Usability
W 3 credits 2S H. Zhao, S. Credé, C. Hölscher

Number of participants limited to 35.
This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.

**Objective**
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a selected usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

**363-0311-00L Psychological Aspects of Risk Management and Technology**

Number of participants limited to 65.

**Abstract**
Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are treated. Three components of risk management (risk identification/evaluation, risk mitigation, risk communication) and underlying psychological and organizational processes are discussed, using company case studies to promote in-depth understanding.

**Objective**
- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organisations
- Know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

This course consists of three main elements:

**A)** Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

**B)** Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

**C)** Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountingeering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

**Content**
The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication
- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty
- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

**Lecture notes / Literature**
There is no script, but slides will be made available before the lectures. There are texts for each of the course topics made available before the lectures.

**Prerequisites / notice**
The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

**851-0742-00L Contract Design I**

This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

**Number of participants limited to 160. Max 80 ETHZ and 80 UZH Students**

**Abstract**
Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to follow the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Students are expected to implement models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gercke (lucas.gercke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gercke (lucas.gercke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).
**Literature**

- Agent-Based Modeling
  [https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2](https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2)

- Social Self-Organization

- Traffic and related self-driven many-particle systems
  Reviews of Modern Physics 73, 1067

- An Analytical Theory of Traffic Flow (collection of papers)
  [https://www.researchgate.net/publication/261629187](https://www.researchgate.net/publication/261629187)

- Pedestrian, Crowd, and Evacuation Dynamics

- The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
  [https://science.sciencemag.org/content/342/6164/1337](https://science.sciencemag.org/content/342/6164/1337)

Further literature will be recommended in the lectures.

**Prerequisites / notice**

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Project Management</td>
<td>assessed</td>
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<table>
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<tr>
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<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<tr>
<td>Negotiation</td>
<td>not assessed</td>
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</tbody>
</table>

| Personal Competencies        | Adaptability and Flexibility| assessed |
|------------------------------| Creative Thinking         | assessed |
|                              | Critical Thinking         | assessed |
|                              | Integrity and Work Ethics | assessed |
|                              | Self-awareness and Self-reflection | assessed |
|                              | Self-direction and Self-management | assessed |

**851-0467-00L From Traffic Modeling to Smart Cities and Digital Democracies**

Number of participants limited to 40.

**Abstract**

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

**Objective**

To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

**Content**

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Literature

Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future
Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/2020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/686.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective-collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f48e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_fkmr1_1?dchild=1&keywords=Coordination+Jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Decentralized Collective Learning for Self-managed Sharing Economies
https://dl.acm.org/doi/abs/10.1145/3277688

Further literature will be recommended in the lectures.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Master's Thesis

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Master thesis are supervised and reviewed by one or several professors and possibly by other persons at the same time. At least one professor has to be a member of a department involved in the study programme (article 2). This regulation is also valid for master thesis taking place outside ETH Zurich.

Abstract
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking.

Objective
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking.

Content
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking. The thesis can be performed either at ETH Zurich, an industrial enterprise, or in a research institution, but has to be advised by one or more professors affiliated with the Master program "Integrated building systems". The responsible supervisor defines the topic in consultation with the student, together with the scope of work, criteria of assessment, and dates of beginning and delivery of the work.

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0414-AAL</td>
<td>Transport Planning</td>
<td>E-</td>
<td>3 credits</td>
<td>6R</td>
<td>K. W. Axhausen</td>
</tr>
</tbody>
</table>

Abstract
The lecture course discusses the basic concepts, approaches and methods of transport planning in both their theoretical and practical contexts.

Objective
The course introduces the basic theories and methods of transport planning.

Content
Basic theoretical links between transport, space and economic development; basic terminology; measurement and observation of travel behaviour; methods of the four stage approach; cost-benefit analysis.

Literature
<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10 credits</td>
<td>6V+3U</td>
<td>G. Felder</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The ability to work with the basics of calculus in a mathematically rigorous way.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>P. Biran, M. Einsiedler</td>
</tr>
<tr>
<td>Objective</td>
<td>- Mastering basic concepts of Linear Algebra</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>- Introduction to mathematical methods</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Basics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Vectorspaces and linear maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Systems of linear equations and matrices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Determinants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Endomorphisms and eigenvalues</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>We will provide German lecture notes and an English translation at latest at the start of the semester.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester. Besides this we also recommend:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In addition we recommend this general introduction into studying mathematics:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>402-1701-00L</td>
<td>Physics I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>W. Wegscheider</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course gives a first introduction to Physics with an emphasis on classical mechanics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>529-0011-01L</td>
<td>General Chemistry (Physical Chemistry) I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. J. Wörner</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Practical Course General Chemistry

**Concepts and Theories**

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>8</td>
<td>12P</td>
<td>H. V. Schönberg, E. C. Meister</td>
</tr>
</tbody>
</table>

**Content**

- Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements.
- Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

**Lecture notes**

- See homepage of the lecture.

**Literature**

- See homepage of the lecture.

**Prerequisites / notice**

- Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung.

### Additional First Year Compulsory Subjects

**Number**  | **Title**                             | **Type** | **ECTS** | **Hours** | **Lecturers** |
-------------|---------------------------------------|----------|----------|-----------|---------------|
| 529-0011-04L | Practical Course General Chemistry | O        | 8 credits| 12P       | H. V. Schönberg, E. C. Meister |

**Abstract**

Information about the practical course will be given on the first day.

**Objective**

- Qualitative analysis (determination of cations and anions), acid-base-equilibria (pH-values, titrations, buffer), precipitation equilibria (gravimetry, potentiometry, conductivity), redoxreactions (syntheses, redox-titrations, galvanic elements), metal complexes (syntheses, complexometric titration).
- Analysis of measured data, vapour pressure, conductivity, calorimetry, solubility.

**Content**

- The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their states of aggregation as well as changes of selected physical values will be recorded and discussed.

**Lecture notes**

- http://www.guetzmacher.ethz.ch/education/labcourses

**Literature**


**Prerequisites / notice**

- Compulsory: online enrolment latest one week after start of the semester

### Electives

**Number**  | **Title**                             | **Type** | **ECTS** | **Hours** | **Lecturers** |
-------------|---------------------------------------|----------|----------|-----------|---------------|
| 529-0011-02L | General Chemistry (Inorganic Chemistry) I | W+       | 3 credits| 2V+1U     | A. Togni |

**Abstract**

Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions.

**Objective**

- Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective
- Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility.

**Lecture notes**

- Copies of the course slides as well as other documents will be provided as PDF files via the moodle platform.

**Literature**


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-03L</td>
<td>General Chemistry (Organic Chemistry) I</td>
<td>W+</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>P. Chen</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.

**Objective**

- Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry.
- Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicity, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intramolecular interactions.

**Lecture notes**

- Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt

**Safety concept**

- https://chab.ethz.ch/studium/bachelor1.html

Data: 18.08.2022 12:39
Autumn Semester 2022
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3. Semester (Physical-Chemical Direction)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4</td>
<td>3V+1U</td>
<td>R. Signorell</td>
</tr>
<tr>
<td>Objective</td>
<td>Introduction to Chemical Reaction Kinetics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Will be provided</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Voraussetzungen: - Mathematik I und II - Allgemeine Chemie I und II - Physikalische Chemie I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>Y. Chu</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introductory course on quantum and atomic physics including optics and statistical physics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Electives

The Bachelor's programme in Interdisciplinary Sciences allows students to choose from any subject taught at a Bachelor level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the 2nd year. See the Programme Regulations 2018 for further details.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0847-00L</td>
<td>Computer Science</td>
<td>W</td>
<td>5</td>
<td>2V+2U</td>
<td>C. Cotrini Jimenez, F. O. Friedrich Wicker</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.</td>
</tr>
</tbody>
</table>
|            | Literature            |      |      |        | Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010  
Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000 |
| 401-2303-00L | Complex Analysis     | W    | 6    | 3V+2U | E. Kowalski                        |
|            | Abstract              |      |      |        | Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem. |
Th. Gamelin: Complex Analysis. Springer 2001  
D. Salamon: "Funktionentheorie". Birkhauser, 2011. (In German)  
K.Jaenich: Funktionentheorie. Springer Verlag  
R.Remmert: Funktionentheorie I. Springer Verlag  
E.Hille: Analytic Function Theory. AMS Chelsea Publications |
| 401-2333-00L | Mathematical Methods of Physics I | W | 6  | 3V+2U | T. H. Willwacher | |
| 402-0205-00L | Quantum Mechanics I  | W    | 10   | 3V+2U | C. Anastasiou                      |
|            | Objective             |      |      |        | Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems. |
|            | Content               |      |      |        | The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory. |
|            | Lecture notes         |      |      |        | Auf Moodle                       |
|            | Literature            |      |      |        | G. Baym, Lectures on Quantum Mechanics  
E. Merzbacher, Quantum Mechanics  
L.I. Schiff, Quantum Mechanics  
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals  
J.J. Sakurai: Modern Quantum Mechanics  
A. Messiah: Quantum Mechanics I  
S. Weinberg: Lectures on Quantum Mechanics |
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Communication</th>
<th>not assessed</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### 402-0255-00L Introduction to Solid State Physics

**W 10 credits 3V+2U C. Degen**

**Abstract**
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.

**Objective**
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, thermal properties of insulators; metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism, superconductivity.

**Lecture notes**
The script will be available on moodle.

**Literature**

**Prerequisites / notice**
Voraussetzungen: Physik I, II, III wünschenswert

### 402-0263-00L Astrophysics I

**W 10 credits 3V+2U S. Lilly**

**Abstract**
This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.

**Objective**
The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principal through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.

**Lecture notes**
A comprehensive “script” (240 pages, with detailed derivations) is provided to students. In addition, all powerpoint slides shown in the lectures are provided.

### 402-0595-00L Semiconductor Nanostructures

**W 6 credits 2V+1U T. M. Ihn**

**Abstract**
The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

**Objective**
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

**Content**
1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

**Lecture notes**

**Literature**
In addition to the lecture notes, the following supplementary books can be recommended:


**Prerequisites / notice**
The course is taught in English.
Eine kommentierte Foliensammlung ist im HCI-Shop erhältlich.

Analytical Competencies assessed

Inorganic Chemistry I
M. Gaberdiel
Introduction into the most important spectroscopical methods and their applications to gain structural information.

H. Grützmacher
2V+1U
Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals as well as the lanthanides and actinides.

assessed
Concepts and Theories
P. Steinegger
W
Script will be for the production price

not assessed
Communication
not assessed
Self-presentation and Social Influence
not assessed
Sensitivity to Diversity
not assessed
Creative Thinking
assessed
Critical Thinking
assessed
Integrity and Work Ethics
assessed
Self-direction and Self-management
not assessed

402-2203-01L Classical Mechanics
W 7 credits 4V+2U M. Gaberdiel
Abstract
A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

Objective
Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

529-0051-00L Analytical Chemistry I
W 3 credits 3G D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi
Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:

- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra;
- Raman spectroscopy.

Prerequisites / notice
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

529-0121-00L Inorganic Chemistry I
W 3 credits 2V+1U H. Grützmacher, P. Steininger
Abstract
Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals as well as the lanthanides and actinides. Introduction of methods of characterization, physical-chemical properties of coordination compounds as well as principles of radiochemistry.

Objective
The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. The students will acquire knowledge on the fundamentals of radioactive decay and radiochemistry. Furthermore, they will be familiar with the basics of inorganic chemistry of lanthanides and actinides.

Content
This course consists of the following parts, which introduce the students to the chemistry of transition metals as well as lanthanides and actinides: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) Properties and characterization of coordination compounds; 9) Introduction to radiochemistry; 10) Principles of the chemistry of the lanthanides and actinides.

Prerequisites

Adaptability and Flexibility
- Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-Atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes

Objective
- The students are able to
  - explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
  - to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
  - to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
  - to explain how mountains influence the atmospheric flow on different scales
  - basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems

Content
- Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-Atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Lecture notes
- Lectures, slides, and additional documents are provided online. Link: https://wennemers.ethz.ch/education.html

Literature
- John H. Seinfeld and Spyros N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, Wiley, New York, 2012. Additional literature will be provided at the beginning of the class and in the lecture notes.

529-0221-00L Organic Chemistry I
- W 3 credits
- 2V+1U H. Wennemers

Abstract
- This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

Objective
- The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.

Content

Lecture notes
- The lecture slides, problem sets, and additional documents are provided online. Link: https://wennemers.ethz.ch/education.html

Literature

701-0023-00L Atmosphere
- W 3 credits
- 2V E. Fischer, T. Peter

Abstract
- Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Objective
- Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate; atmosphere - ocean - continents; troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Content
- Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Lecture notes
- Written information will be supplied.

Literature

701-0461-00L Numerical Methods in Environmental Physics
- W 3 credits
- 2G C. Schär, C. Zeman

Abstract
- This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.

Objective
- Ability to develop simple numerical schemes and to implement these schemes using the programming language Python. Ability to critically use more complex numerical models.

Content
- Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration schemes, non-linearly, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-section of Environmental Science.

Lecture notes

Literature
- List of literature is provided.

701-0473-00L Weather Systems
- W 3 credits
- 2G M. A. Sprenger, F. Scholder-Aemessinger

Abstract
- Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes

Objective
- The students are able to
  - explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
  - to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
  - to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
  - to explain how mountains influence the atmospheric flow on different scales
  - basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems

Content
- Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Lecture notes
- I Lecture notes and slides

Literature
- Atmospheric Science, An Introductory Survey
- John M. Wallace and Peter V. Hobbs, Academic Press
### Atmospheric Physics

**W 3 credits 2G F. Mahrt**

**Abstract**  
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.

**Objective**  
Students are able to:  
- to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.  
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

**Content**  
The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to classify radiosondes with the help of the thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

**Lecture notes**  
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15367

**Prerequisites / notice**  
For certain capters we'll use the concept of "flipped classroom" (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

**Taught competencies**  
Subject-specific Competencies: Concepts and Theories  
Method-specific Competencies: Analytical Competencies

2 credits 2V R. Kretzschmar

### Pedosphere

**W 3 credits 2V R. Kretzschmar**

**Abstract**  
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

**Objective**  
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

The course "Pedosphäre" teaches and examines the competences process understanding and systems understanding.

**Content**  
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

**Lecture notes**  
Polybook  

**Prerequisites / notice**  
Prerequisites: Basic knowledge in chemistry, biology and geology.

**Taught competencies**  
Subject-specific Competencies: Concepts and Theories  
Method-specific Competencies: Techniques and Technologies

### Microbiology

**W 2 credits 2V M. Ackermann, M. Schuppler, J. Vorholt-Zambelli**

**Abstract**  
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

**Objective**  
Teaching of basic knowledge in microbiology.

**Content**  

**Lecture notes**  
Wird von den jeweiligen Dozenten ausgegeben.

**Literature**  
Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

### Laboratory Courses, Semester Papers, Proseminars, Field Trips

**Further laboratory courses must be applied for at the respective Director of Studies.**

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#### 701-0475-00L Atmospheric Physics

- **Type:** Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.
- **Content:** The course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.
- **Objective:** Students are able to:  
  - to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.  
  - to evaluate the significance of clouds and aerosol particles for artificial weather modification.
- **Lecture notes:** Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15367
- **Prerequisites / notice:** For certain capters we’ll use the concept of “flipped classroom” (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning.
- **Taught competencies:** Subject-specific Competencies: Concepts and Theories

#### 701-0501-00L Pedosphere

- **Type:** Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.
- **Lecture notes:** Polybook  
- **Prerequisites / notice:** Prerequisites: Basic knowledge in chemistry, biology and geology.
- **Taught competencies:** Subject-specific Competencies: Concepts and Theories

#### 752-4001-00L Microbiology

- **Type:** Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.
- **Lecture notes:** Wird von den jeweiligen Dozenten ausgegeben.
- **Literature:** Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

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**Data:** 18.08.2022 12:39  
**Autumn Semester 2022**  
**Page 1307 of 2345**
Abstract
Qualitative analysis (determination of cations and anions), acid-base-equilibria (pH-values, titrations, buffer), precipitation equilibria (gravimetry, potentiometry, conductivity), redox-reactions (syntheses, redox-titrations, galvanic elements), metal complexes (syntheses, complexometric titration).

Objective
Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation state and redox behaviour (syntheses), redox-titrations, galvanic elements, metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration) analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimetry, solubility).

Content
The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their states of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes
http://www.gruetzmacher.ethz.ch/education/labcourses

Literature

Prerequisites / notice
Compulsory: online enrolment latest one week after start of the semester
Safety concept: https://chab.ethz.ch/studium/bachelor1.html

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-0129-00L</td>
<td>Inorganic and Organic Chemistry II</td>
<td>W</td>
<td>11 credits</td>
<td>16P</td>
<td>V. Mougel</td>
</tr>
</tbody>
</table>

Abstract
Latest online enrolment is one week before the beginning of the semester.

Objective
Introduction to the experimental methods of Inorganic Chemistry

Content
The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a main topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques. Emphasis is given to scientific writing (experiment reports).

Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Lecture notes
A manual is distributed in the teaching laboratory.

Prerequisites / notice
- Passed Basisprüfung
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)
- Continuous Attendance of Course Inorg. Chemistry 1 (3. Sem., 529-0121) and Analytical Chemistry 1 (3. Sem., 529-0051)

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Theories: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

5. Semester (Physical-Chemical Direction)

Laboratory Courses, Semester Papers, Proseminars, Field Trips

Further laboratory courses must be applied for at the respective Director of Studies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>529-0450-00L</td>
<td>Semester Project</td>
<td>W</td>
<td>18 credits</td>
<td>18A</td>
<td>Supervisors</td>
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</tbody>
</table>

Abstract
In a semester project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic.

Objective
Students are accustomed to scientific work and they get to know one specific research field.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>402-0000-09L</td>
<td>Physics Lab 3</td>
<td>W</td>
<td>7 credits</td>
<td>13P</td>
<td>M. Donegà, S. Gvasaliya</td>
</tr>
</tbody>
</table>
The lecture follows the book "Physics" by Paul A. Tipler.

We offer experiments covering the following topics:
- Basic topics from mechanics, optics, thermodynamics, electromagnetism and electronics; as well as central topics from nuclear and particle physics, quantum electronics, quantum mechanics, solid state physics and astrophysics.

Bachelor's Thesis

1. Semester (Biochemical-Physical Direction)

Compulsory Subjects First Year Examinations

Abstract

The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

Objective

The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

The newly conceived lecture is supported by scripts.
Literature
The lecture is supported by scripts.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecture Units</th>
<th>Instructor</th>
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<tr>
<td>401-0271-00L</td>
<td>Mathematical Foundations I: Analysis A</td>
<td>5</td>
<td>3V+2U</td>
<td>M. Felder</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Introduction to calculus in one dimension. Building simple models and analysing them mathematically. Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.</td>
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<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag R. Sperb/M. Akveld: Analysis I (vdf) L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg further reading suggestions will be indicated during the lecture</td>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<th>Lecture Units</th>
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<tr>
<td>529-0011-02L</td>
<td>General Chemistry (Inorganic Chemistry) I</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Togni</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
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<tr>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<tr>
<td>529-0011-03L</td>
<td>General Chemistry (Organic Chemistry) I</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Chen</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Introduction to Organic Chemistry. Classical structure theory, stereochmistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry.</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicality, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intermolecular interactions.</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<tr>
<td></td>
<td>Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1310 of 2345
Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Negotiation

529-0011-01L General Chemistry (Physical Chemistry) I

Abstract
The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.

Objective
After the lecture, students will be able to,
- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- analyze and calculate absorption and emission spectra of single-electron atoms,
- to set up the Schrödinger equation for a molecular multi-particle system,
- independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems,
- model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model,
- explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom,
- explain the structure of the periodic table of elements with the help of the orbital concept,
- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and
- establish term symbols for atomic ground states.

Content
Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, and symbols. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

Lecture notes
See homepage of the lecture.

Literature
See homepage of the lecture.

Prerequisites / notice
Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung.

Taught competencies

Subject-specific Competencies
- Subject-specific Competencies
- Concepts and Theories
- assessed
- assessed

Method-specific Competencies
- Analytical Competencies
- assessed

Social Competencies
- Communication
- not assessed

Personal Competencies
- Adaptability and Flexibility
- not assessed

Additional First Year Compulsory Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-04L</td>
<td>Practical Course General Chemistry</td>
<td>O</td>
<td>8</td>
<td>12P</td>
<td>H. V. Schönberg, E. C. Meister</td>
</tr>
</tbody>
</table>

Abstract
Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity, oxidation state and redox behaviour (syntheses), redox-titrations, galvanic elements), metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration) analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimetry, solubility).

Objective
The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their states of aggregation as well as changes of selected physical values will be recorded and discussed.

Content

Lecture notes
http://www.gruetzmacher.ethz.ch/education/labcourses


Literature
Moodle Lernplattform

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1311 of 2345
### 3. Semester (Biochemical-Physical Direction)

#### Examination Block

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0373-00L</td>
<td>Mathematics III: Partial Differential Equations</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>L. Keller</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Classical tools to solve the most common linear partial differential equations.

1. Examples of partial differential equations
   - Classification of PDEs
   - Superposition principle
2. One-dimensional wave equation
   - D'Alembert's formula
   - Duhamel's principle
3. Fourier series
   - Representation of piecewise continuous functions via Fourier series
   - Examples and applications
4. Separation of variables
   - Solution of wave and heat equation
   - Homogeneous and inhomogeneous boundary conditions
   - Dirichlet and Neumann boundary conditions
5. Laplace equation
   - Solution of Laplace's equation on the rectangle, disk and annulus
   - Poisson formula
   - Mean value theorem and maximum principle
6. Fourier transform
   - Derivation and definition
   - Inverse Fourier transformation and inversion formula
   - Interpretation and properties of the Fourier transform
7. Laplace transform (if time allows)
   - Definition, motivation and properties
   - Inverse Laplace transform of rational functions
   - Application to ordinary differential equations

**Lecture notes**
See the course web site (linked under Lernmaterialien)

**Literature**


Additional books:
4. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1,2,11,12,6)

For additional sources, see the course web site (linked under Lernmaterialien)

**Prerequisites / notice**

Required background:
1. Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant
2. Multiple integrals: Riemann integrals in two or three variables, change of variables
2. Sequences and series of numbers and of functions
3. Basic knowledge of ordinary differential equations

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4</td>
<td>3V+1U</td>
<td>R. Signorelli</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Introduction to Chemical Reaction Kinetics

**Content**

**Lecture notes**
Will be provided

**Literature**

For more information about the lecture: [www.csms.ethz.ch/education/Info](http://www.csms.ethz.ch/education/Info)

### 5. Semester (Biochemical-Physical Direction)

#### Laboratory Courses, Semester Papers, Proseminars, Field Trips

Further laboratory courses must be applied for at the respective Director of Studies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0450-00L</td>
<td>Semester Project</td>
<td>W</td>
<td>18</td>
<td>18A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>529-0400-00L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>15</td>
<td>15D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

#### Bachelor's Thesis

- In a semester project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic.
- It completes the Bachelor program and consists of a scientific project carried out independently.
- Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

### Second and Third Year Additional Subjects

The Bachelor's programme in Interdisciplinary Sciences allows students to choose from any subject taught at a Bachelor level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the 2nd year. See the Programme Regulations 2018 for further details.

### Other Electives ETH

Further combinations of compulsory elective subjects arising upon specific written request by the students and permission by the Director of studies.

- Selection of courses from entire course catalogue of ETH, according to individual study plan

### Science in Perspective

#### Science in Perspective

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-CHAB

### Language Courses

- see Science in Perspective: Language Courses ETH/UZH
### Interdisciplinary Sciences Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>W+</th>
<th>W</th>
<th>E-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>Eligible for credits and recommended</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>Eligible for credits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Recommended, not eligible for credits</td>
<td></td>
<td></td>
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</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>P</th>
<th>A</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>practical/laboratory course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>independent project</td>
<td></td>
<td></td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>diploma thesis</td>
<td></td>
<td></td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>revision course / private study</td>
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<td></td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Interdisciplinary Sciences Master

The Master's programme in Interdisciplinary Sciences allows students to choose from any subject taught at the Master's level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the Master's programme. See the Programme Regulations 2007/2020 for further details.

▸ Majors

The following list provides various Majors that can be chosen from: https://ethz.ch/content/dam/ethz/special-interest/chab/chab-dept/studies/documents/IN/WL_IN_SR19192101_EN.pdf

In addition it is possible to create an individual Major in accordance with the Programme Regulations (Art. 19 paragraph 3).

Selection of courses from entire course catalogue of ETH, according to individual study plan

▸ General Courses

Selection of courses from entire course catalogue of ETH, according to individual study plan

▸ Proseminars, Laboratory Courses, Research Projects and Sem. Papers

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
529-0020-00L | Research Project | W | 20 credits | 20A | Supervisors
Abstract | In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.
Objective | Students are accustomed to scientific work and they get to know one specific research field.

Selection of courses from entire course catalogue of ETH, according to individual study plan

▸ Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

see Science in Perspective: Language Courses ETH/UZH

▸ Master's Thesis

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
529-1000-00L | Master's Thesis | O | 20 credits | 43D | Supervisors
Abstract | Only students who fulfill the following criteria are allowed to begin with their Master's thesis:
a. successful completion of the Bachelor's programme;
b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.
Duration of the Master's Thesis: 4 months.
Objective | In the Master's thesis students prove their ability to independent, structured and scientific working. The Master's thesis is usually carried out in a core or optional subject area as chosen by the student.

529-1000-30L | Master's Thesis | W | 30 credits | 64D | Supervisors
Abstract | Only students who fulfill the following criteria are allowed to begin with their Master's thesis:
a. successful completion of the Bachelor's programme;
b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.
Duration of the Master's Thesis 6 months, possible only with permission of the Director of Studies.
Objective | In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is usually carried out in a core or optional subject area as chosen by the student.

Interdisciplinary Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Interdisciplinary Brain Sciences Master

### Core Modules

The Core Modules take place at University of Zurich: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Core-Modules.html

### Elective Core Modules

Courses listed here take place at ETH Zurich.

Further courses and a complete list of the Elective Core Modules can be found here: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Elective-Core-Modules.html

Please register for ETH-courses at ETH Zurich, for UZH-courses at UZH.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-1414-00L</td>
<td>Current Topics in Brain Research (HS)</td>
<td>W</td>
<td>1 credit</td>
<td>1.5K</td>
<td>I. Mansuy, further lecturers</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Different national and international scientific guests are invited to present and discuss their actual scientific results.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>To exchange scientific knowledge and data and to promote communication and collaborations among researchers. For students: Critical discussion of current research. Students aiming at getting a credit point for this colloquium choose one topic and write a critical essay on the presented research topic.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Different scientific guests working in the field of molecular cognition, neurochemistry, neuromorphology and neurophysiology present their latest scientific results.</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<tr>
<td></td>
<td>no handout</td>
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<td><strong>Literature</strong></td>
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<td></td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Some of the seminars will be shared with the Institute of Neuroinformatics (INI) of UZH.</td>
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</table>

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1219-00L</td>
<td>Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Riener, O. Lambercy</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution. This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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</tr>
<tr>
<td></td>
<td>Introduction, problem definition, overview</td>
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<tr>
<td></td>
<td>Rehabilitation of visual function</td>
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<tr>
<td></td>
<td>- Anatomy and physiology of the visual sense</td>
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<td></td>
<td>- Technical aids (glasses, sensor substitution)</td>
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<td></td>
<td>- Retina and cortex implants</td>
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<tr>
<td></td>
<td>Rehabilitation of hearing function</td>
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<tr>
<td></td>
<td>- Anatomy and physiology of the auditory sense</td>
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<td></td>
<td>- Hearing aids</td>
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<tr>
<td></td>
<td>- Cochlea Implants</td>
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<tr>
<td></td>
<td>Rehabilitation and use of kinesthetic and tactile function</td>
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<tr>
<td></td>
<td>- Anatomy and physiology of the kinesthetic and tactile sense</td>
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<tr>
<td></td>
<td>- Tactile/haptic displays for motion therapy (incl. electrical stimulation)</td>
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<tr>
<td></td>
<td>- Role of displays in motor learning</td>
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<tr>
<td></td>
<td>Rehabilitation of vestibular function</td>
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<tr>
<td></td>
<td>- Anatomy and physiology of the vestibular sense</td>
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<tr>
<td></td>
<td>- Rehabilitation strategies and devices (e.g. BrainPort)</td>
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<tr>
<td></td>
<td>Rehabilitation of vegetative Functions</td>
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<tr>
<td></td>
<td>- Cardiac Pacemaker</td>
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<tr>
<td></td>
<td>- Phrenic stimulation, artificial breathing aids</td>
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<tr>
<td></td>
<td>- Bladder stimulation, artificial sphincter</td>
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<tr>
<td></td>
<td>Brain stimulation and recording</td>
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<tr>
<td></td>
<td>- Deep brain stimulation for patients with Parkinson, epilepsy, depression</td>
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<tr>
<td></td>
<td>- Brain-Computer Interfaces</td>
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</tbody>
</table>
**Methods & Models for fMRI Data Analysis**

This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0971-00L</td>
<td>Computational Psychiatry</td>
<td>3</td>
<td>K. Stephan</td>
</tr>
</tbody>
</table>

**Objective**

This course aims at bridging the gap between mathematical modelers and clinical neuroscientists by teaching computational techniques in the context of clinical applications. The hope is that the acquisition of a joint language and tool-kit will enable more effective communication and joint translational research between fields that are usually worlds apart.

**Content**

This course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/ for details.

**Literature**


**Selected Journal Articles and Web Links:**


VideoTact, ForeThought Development, LLC. http://my.execpc.com/?dwysocki/videotac.html

Target Group:

- Students of higher semesters and PhD students of
  - D-MAVT, D-ITET, D-INFK, D-HEST
  - Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Autumn Semester 2022

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Professor</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0969-00L</td>
<td>Methods &amp; Models for fMRI Data Analysis</td>
<td>6</td>
<td>K. Stephan</td>
</tr>
</tbody>
</table>

**Objective**

To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

**Abstract**

This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

**Neuromorphic Engineering I**

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**

Understanding of the characteristics of neuromorphic circuit elements.

**Content**

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

**Literature**

A. Blasimme; T. Delbrück; S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

**Prerequisites / notice**

Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools. Prerequisites: Background in basics of semiconductor physics helpful, but not required.

**Applied Analysis of Variance and Experimental Design**

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Objective**

Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**


**Theory of Robotics and Mechatronics**

Does not take place this semester.

**Objective**

Robotics is often viewed from three perspectives: perception (sensing), manipulation ( affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**

An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Ethics of Life Sciences and Biotechnology**

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

**Objective**

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.
Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Internship

Further information: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Internship.html

Master’s Thesis and Exam


Interdisciplinary Brain Sciences Master - Key for Type

| O  | Compulsory |
| W+ | Eligible for credits and recommended |
| W  | Eligible for credits |
| E- | Recommended, not eligible for credits |
| Z  | Courses outside the curriculum |
| Dr | Suitable for doctorate |

Key for Hours

| V  | lecture |
| G  | lecture with exercise |
| U  | exercise |
| S  | seminar |
| K  | colloquium |
| P  | practical/laboratory course |
| A  | independent project |
| D  | diploma thesis |
| R  | revision course / private study |

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**Landscape Architecture Master**

► **Compulsory Basic Courses**

All basic courses (in terms of content and methodology linked to "Foundation Studio I") must be completed.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>061-0101-00L</td>
<td>Ecology and Plant Sciences</td>
<td>O</td>
<td>2 credits</td>
<td>3G</td>
<td>T. Gall-Izard, A. Guggisberg, J. Hille Ris Lambers, M. Lévesque, J. Luster, A. Rudow, R. Kretzschmar</td>
</tr>
</tbody>
</table>

**Abstract**

Lectures, exercises and excursions serve as an introduction to atmospheric sciences, hydrology and soil science. Students gain a broad vision of the cutting edge topics that are being researched and studied at the Department of Environmental Systems Science at ETH, Eawag, WSL a.o. This will be the base for a future dialog between the field of landscape architecture and the field of sciences.

**Objective**

Students acquire basic knowledge in atmospheric sciences, hydrology and soil science:
- Understanding basic chemical and physical processes in the atmosphere that influence weather and climate
- Knowledge of water balance, principles of integral water management and climatic factors in the field of hydrology
- Fundamentals about the classification of soils, soil-forming processes, physical and chemical soil properties, soil biology and ecology, soil degradation and protection

Students develop an understanding of the relevance of these topics in the field of landscape architecture. Temporal and physical scale, research methods, units of measurement, lexicon, modes of representation and critical literature form the framework for the joint discourse.

**Content**

The course unit consists of the three courses "Climate", "Water" and "Soil", which are organized in modules.

Module 1 "Climate", 19.–23.09.2022
- Atmospheric dynamics: weather conditions, precipitation formation, weather forecast
- Climate physics: past and future changes in global climate and scenarios for Switzerland
- Land-climate dynamics: interaction between the land surface and the climate system
- Hydrology and water cycle: extreme precipitation, influence of climate change on the cryosphere

Module 2 "Water", 26.09.–30.09.2022
- Basics:
  - Water supply: water balance, groundwater, water quality (water protection)
  - Hydrological hazards: floods and drought
  - Water use: drinking water, hydropower, ecology
- External influencing factors: human influence in the historical dimension, global change
- "Hydrology of drought" and its impact on water resources.

Module 3 "Soil", 3.10.–7.10.22
- Introduction to soils; definition, function, formation, classification and mapping
- Soil physics: soil texture, soil structure, soil water potentials, hydraulic conductivity
- Soil chemistry and fertility: clay minerals and oxides, cation exchange capacity, soil pH, essential plant nutrients
- Soil biology and ecology: soil fauna and microflora, fungi, bacteria, food web, organic matter
- Soil degradation and threats to soil resources: erosion, compaction, sealing, contamination, salinization
- Practical aspects of soil protection

**Lecture notes**

The course material includes a reading list.

**Literature**

Course material will be provided.

**Prerequisites / notice**

The courses "Climate", "Water" and "Soil" are organized with the Fundamental Studio I as joint one-week modules. The weekly schedules will be provided with the course materials.

Module 1 "Climate", 19.–23.09.2022
Module 2 "Water", 26.09.–30.09.2022
Module 3 "Soil", 3.10.–7.10.22

- The courses are held in English or German.
- The written session examination covers all three courses "Climate", "Water" and "Soil".
- During the excursions there will be at least one external overnight stay.

**Taught competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies

**Social Competencies**
- Communication
- Cooperation and Teamwork

**Personal Competencies**
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
Abstract
This course introduces ecology and plant sciences. Through lectures, exercises and excursions, students will gain a broad vision of the cutting edge topics that are being researched and studied at the Department of Environmental Systems Science at ETH. This will be the basis for a future dialogue between the field of landscape architecture and the field of sciences.

Objective
Students acquire basic knowledge in ecology and plant sciences focusing in its application in the field of landscape architecture. Temporal and physical scale, research methods, units of measurement, lexicon, modes of representation and critical literature form the framework for the joint discourse.

Content
The fundamental course "Ecology and Plant Sciences" is an introduction to the field of living systems, starting with the history of ecology, followed by an introduction to plant systematics, taxonomy and physiology. The course will also introduce students to the specifics of the rhizosphere, disturbance ecology and forests. Lastly, the course will focus on the specifics of tree structure and function.

Lecture notes
Course material will be provided.

Literature
The course material includes a reading list.

Prerequisites / notice
The fundamental course is organized with the Fundamental Studio I as a joint two-week module. The weekly schedule is provided with the course documents.

Module 4 "Ecology and Plant Sciences", 10.10.–21.10.2022

The course is held in English.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<table>
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<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
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<tbody>
<tr>
<td></td>
<td>Decision-making</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<table>
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<tr>
<th>Social Competencies</th>
<th>Communication</th>
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<td>Cooperation and Teamwork</td>
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<th>Personal Competencies</th>
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<th>assessed</th>
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<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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</table>

061-0105-00L Designing with Plants I

Abstract
This fundamental course provides an introduction to the basics of botany and forms a solid foundation of knowledge for the following semesters. The course covers the following areas: Species knowledge of native shrubs and trees in autumn and winter conditions and their habitat requirements, introduction to the identification of plants and consolidation of botanical terms.

Objective
Students will be introduced to botany and after the course they will be able to identify about sixty native trees and shrubs in order to use them appropriately in their designs. They will be familiar with botanical terms, which will enable them to have a high level of understanding of botanical literature.

Content
This course focuses on excursions with a botanical expert. In addition, the students are supported by theoretical and conceptual lectures. This gives the students a good basis of botanical knowledge, which can be professionally integrated into their designs. This module is organized together with the Foundation Studio I, so that the knowledge imparted can directly influence the designs. The module is divided into different subject areas:

1) Consolidation of botanical terms. These form the basis for the identification and recognition of plants. The most important technical terms are explained and illustrated with suitable plant material.

2) Species knowledge is taught on regular field excursions and supplemented with theoretical input. The species can also be studied in the classroom using fresh material. In addition to site characteristics and seasonal changes, growth forms are also taught.

3) Through the introduction to identification, the students will understand how a simple identification key is constructed and how it is used, so that unknown species can be identified independently.

Lecture notes
The notes or reader will be distributed during the course.

Literature
The relevant literature and content for the examination will be indicated during the course.

Prerequisites / notice
The course is aimed exclusively at the students of the Master's programme in landscape architecture. The detailed course schedule is published on the course website (and is included in the reader).

The lectures might take place outside. It is necessary to foresee clothes adapted to the weather.
This course focuses on techniques for modifying ground conditions. The shape and material properties of the ground is fundamental for how water moves, what vegetation grows and how changes in microclimatic conditions manifest on site. For landscape architects, learning the mechanisms for transforming the surface of the earth opens up site-based design possibilities. Through a series of short exercises and on-site fieldwork, this course teaches the fundamental techniques of land and water manipulation, focusing on earthwork, drainage, soil and basic construction methods. Students learn analog and digital grading techniques, working with landform modification in Rhino and Grasshopper. During the two-week module, students will do a close study, both on and off site, of two landscapes: the designed urban quarry of Parc de Buttes Chaumont in Paris and the 2022 Foundation Studio I site, a gravel quarry in Lleida, Spain.

Material and Construction I (7th November – 18th November 2022) is closely linked to the Foundation Studio I.

The fundamental course Materials and Construction I is aimed exclusively at the students of the master's program in landscape architecture. The detailed course schedule is provided at the beginning of the semester and is included in the reader. The reader is handed out during the week prior to the module. Relevant literature is included in the reader.
Abstract
This course covers basic positions of philosophical ethics with a strong emphasis on central debates in landscape architecture.

Objective
The course aims to provide basic knowledge of concepts and terms within moral philosophy; engage with current debates in landscape architecture through lectures, text analysis, discussions and presentations; develop an understanding of the relation between science/society/design as well as practice and theory; help establish one's own design attitude; provide tools for argumentation; put to practice scientific working methods.

Content
Between the poles of theory and practice and through the development of a foundation in ethics, the students' sensitivity for ecological, political and social issues will be awakened and strengthened. In response to current issues touched upon in the disciplinary media or journalism, we will reflect upon the role of landscape architects in today's society as well as one's own individual attitude within the profession. The overall goal is for students to gain a critical understanding of a range of design approaches as well as an awareness of the specific role of design and design quality in the context of ethical debates.

Texts will be read in German and English.

Lecture notes
Detailed information regarding the course will be communicated at the beginning of the semester.

Literature
The course material includes a reading list.

Prerequisites / notice
The course takes place as a block course alternating with "History and Theory of Landscape Architecture I".

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed

061-0113-00L Digital Design Methods I
Only for Landscape Architecture MSc.

Abstract
This course introduces digital design methods in landscape architecture from data acquisition and modelling, to simulation and visualization.

Objective
Students know the most relevant survey methods, landscape modelling tools as well as simulation and visualization techniques. They are able to use those methods independently in the following semesters and in practice.

Content
Based on a case study, the students work on the entire workflow of a landscape architectural project:

1. Survey
2. Modelling
3. Analysis, Simulation, Visualization

The case study will serve as a synthesis project where the students can apply their acquired skills. During the course, students are supported by an interdisciplinary team in the development of their case study. The case study will be conducted in teams of two students.

Digital and physical learning material is provided throughout the course.

Lecture notes
We recommend to attend the one-week preparatory workshop from September 12-16, 2022! For registration please contact the lecturers until August 15, 2022.

Prerequisites / notice

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Media and Digital Technologies assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed

Core Courses
Compulsory Core Courses
Courses are offered in Spring Semester.

Elective Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>052-0717-22L</td>
<td>Territory of the City: Turin</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>G. Vogt</td>
</tr>
</tbody>
</table>

Abstract
The elective deals with current transformation processes of metropolitan landscapes in Europe and introduces landscape architecture design on a territorial scale. On the basis of cartographic analysis and field trips, students will develop concrete strategies for the urban landscape of the Città Metropolitana di Torino.

Objective
The elective introduces to the subject and complexity of the urbanized landscape and teaches the critical engagement with the challenges and potentials of current tendencies in Landscape Architecture. On the basis of a concrete study area, students examine the large-scale processes of reuse, reform and reinterpretation of metropolitan landscapes in Europe and develop new approaches and strategies on various scales. They become familiar with GIS as an analytical tool, model building as a design methodology and the representation of landscape through plans. They develop a project based on the perception of place, knowledge of landscape-architectonic typologies and conception of public space. The design process is accompanied by workshops, lectures, excursions, critiques and a workbook.

Content
The elective is offered in the second semester and is linked to the subject and complexity of the urbanized landscape. Students will develop concrete strategies for the urban landscape of the Città Metropolitana di Torino through a series of short exercises. They become familiar with GIS as an analytical tool, model building as a design methodology and the representation of landscape through plans. They develop a project based on the perception of place, knowledge of landscape-architectonic typologies and conception of public space. The design process is accompanied by workshops, lectures, excursions, critiques and a workbook.

Compensatory Course for Core Courses
In the first semester of the curriculum no compensation courses for compulsory courses offered.

Advanced Courses
In the first semester of the curriculum there are no main courses offered.

Design Studios
The design studios deal with problem and practice-related tasks on a local, regional, supra-regional, national and international level. Teaching of digital analysis, design and planning methods.

Foundation Studio I and II
- Fundamental Studio I: basic knowledge;
- Fundamental Studio II: Design tasks in the context of the contemporary landscape;

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>061-0141-22L</td>
<td>Foundation Studio I</td>
<td>W</td>
<td>14</td>
<td>26U</td>
<td>T. Galí-Izard</td>
</tr>
</tbody>
</table>

Abstract
This course introduces a design methodology for landscape architecture that emphasizes the design of living systems and dynamic landscape processes in dialogue with the environmental sciences. With a focus on translating and synthesizing scientific information through rigorous drawing and critically engaging with the primary matter of landscapes, this course teaches core tools of the discipline.

Objective
Through a series of short exercises, students acquire essential analytical and methodological skills to support design in the field of Landscape Architecture.

Content
This course introduces a design methodology for landscape architecture that emphasizes the design of living systems and dynamic landscape processes in dialogue with the environmental sciences. With a focus on translating and synthesizing scientific information through rigorous drawing and critically engaging with the primary matter of landscapes, this course teaches core tools of the discipline.

The Foundation Studio I in the autumn semester 2022 engages with an active gravel quarry in the territory of Lleida, Spain. Throughout the semester, students situate the local climatic, geologic, hydrological, pedological and vegetative processes in a larger context, and make proposals that respond to the specific potentials of the site.

The semester is composed of six modules, which are linked to the respective fundamental course, and a synthesis module:
- Climate Module, 19-23.09.2022
- Water Module, 26-30.09.2022
- Soil Module, 03-08.10.2022
- Ecology and Plant Sciences Module, 10-21.10.2022
- Designing with Plants I Module, 31.10-04.11.2022 and 21-25.11.2022
- Materials and Construction I Module, 07-18.11.2022
- Synthesis Module, 28.11–23.12.2022

The general course structure includes lectures and other theoretical inputs in the morning (fundamental courses) and studio in the afternoon, working with these same topics as generators for design proposals.
The reader is handed out during the first week of the semester. Relevant literature is included in the reader.


The weekly schedule is published at the beginning of the semester and is included in the reader.

Classes (and critiques) are held in English.

No course 24th-28th of October 2022 (seminar week).

Five walks lead us through the territory of the city of Basel. The tri-national area (Germany, Switzerland, France) with its exceptional geological, topographical, hydrological and climatic situation has a specific and diverse vegetation. We discover this diversity on the walks as a way of exploring the urban landscape from a pedestrian perspective.

The program is contextualized by dealing with the topic of walking science. Markus Ritter introduces the theory and method of promenadology in evening lectures, seminars and reading sessions, focusing on the person of Lucius Burckhardt (sociologist, 1925 - 2003).

The walks are led by proven experts. In conversations, Sonja Hassold (biologist), Günther Vogt (landscape architect) and Markus Ritter (ecologist) explain the relationships between the vegetation found and the conditions of the landscape. In doing so, references are made to the political, social and economic influencing factors that regulate the development of the landscape and significantly influence its shape.

The internship report should cover as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.

The report can be written in German or English language.

Advanced Studio

Complex design tasks involving social, topographical, hydrological and ecological issues.

Seminar Week and Internship Report

In MScLA at least one week of seminar must be completed. Furthermore, part of the course is a six-month internship in the field of landscape architecture, the achievements (work phases, learning success) must be documented in an internship report.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>061-0153-00L</td>
<td>Internship Report</td>
<td>O</td>
<td>2</td>
<td>4P</td>
<td>T. Gali-Izard, G. Vogt</td>
</tr>
</tbody>
</table>

Abstract
Part of the course is a six-month internship in the field of landscape architecture. The internship should include as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.

Objective
The internship report should cover as many work phases as possible in the work of a landscape architect.

Content
Part of the course is a six-month internship in the field of landscape architecture. The internship should include as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.

Prerequisites / notice
Internship report (of 6 months, within the field of landscape architecture). The report can be written in German or English language.

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>061-0151-22L</td>
<td>Seminar Week Autumn Semester 2022</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>T. Gali-Izard</td>
</tr>
</tbody>
</table>

Does not take place this semester.
Only for Landscape Architecture MSc.

Abstract
Along five walks we explore the city vegetation of Basel and built connections to the conditions of the surrounding landscape. Obtaining a panoptical view of the “nature of the city” is the goal of intensive study of the territory.

Objective
In addition to a comprehensive insight into the vegetation of the city of Basel, the students receive an introduction to the method of walking as a way of exploring the urban landscape from a pedestrian perspective.

Content
Five walks lead us through the territory of the city of Basel. The tri-national area (Germany, Switzerland, France) with its exceptional geological, topographical, hydrological and climatic situation has a specific and diverse vegetation. We discover this diversity on the walks in the Petite Camargue, on the Tüllinger Hügel, during the crossing of the Jura and in the parks within the city.

The walks are led by proven experts. In conversations, Sonja Hassold (biologist), Günther Vogt (landscape architect) and Markus Ritter (ecologist) explain the relationships between the vegetation found and the conditions of the landscape. In doing so, references are made to the political, social and economic influencing factors that regulate the development of the landscape and significantly influence its shape.

The program is contextualized by dealing with the topic of walking science. Markus Ritter introduces the theory and method of promenadology in evening lectures, seminars and reading sessions, focusing on the person of Lucius Burckhardt (sociologist, 1925 - 2003).

The costs for the seminar trip (24.10.-30.10.) range between 251.- and 500.- (cost framework B). Included are: All overnight stays (including breakfast), a dinner together, transfers from the hotel to the excursions, reader and all costs for admission to museums.

The course is aimed exclusively at students of the master's program in landscape architecture.

It is highly recommended to participate this Seminar Week in preparation for the Module 5 (061-0105-00L Designing with Plants I) and the lecture Designing with Plants II (061-0106-00L).
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

Science in Perspective

Courses of the "Science in Perspective" programme have to be completed (details see study guidelines Art. 27).

Recommended Science in Perspective (Type B) for D-ARCH

see Science in Perspective: Language Courses ETH/UZH

Master’s Thesis

The master’s thesis is the successful completion of the course. It confirms the ability to work independently in the field of landscape architecture and is tutored by D-ARCH professors (for details see Art. 30 of the study regulations).

Number Title Type ECTS Hours Lecturers
061-0900-00L Master's Thesis O 30 credits 64D Professors

Abstract
Only students who fulfill the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

The master's thesis concludes the course. It shows the ability of the students to do independent design work and is proof of the successful completion of their studies. It is under the direction of professors from D-ARCH.

The processing time for the master's thesis is fourteen weeks.

Prerequisites / notice

The Master Thesis in Landscape Architecture begins 5th September 2022 and ends 12th December 2022.

Landscape Architecture Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>O</td>
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</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
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<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Educational Science

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are presented in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Prerequisites / notice**

This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects ■ W</td>
<td></td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
</tbody>
</table>

**Abstract**

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

**Objective**

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

**Prerequisites / notice**

Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

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<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>851-0242-07L</td>
<td>Human Intelligence ■ W</td>
<td></td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**

The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

**Objective**

- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tbody>
<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science ■ W</td>
<td></td>
<td>1</td>
<td>2S</td>
<td>C. M. Thurm, T. Braas, P. Edelsbrunner</td>
</tr>
</tbody>
</table>

**Abstract**

Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

**Objective**

- Understanding research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ) ■</td>
<td></td>
<td>2</td>
<td>3S</td>
<td>U. Markwalder, S. Maurer, S. Peterander-Rüschoff</td>
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</tbody>
</table>

The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons.

Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. Finally, a small group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>752-9020-00L</td>
<td>Teaching Internship Including Examination Lessons Food Science</td>
<td>W</td>
<td>6 credits</td>
<td>13P</td>
<td>G. Kaufmann</td>
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</table>

**Subject Didactics and Professional Training**

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

**Prerequisites**

- Students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.
- Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).
- Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

**Prerequisites / notice**

- Students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.
- Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).
- Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.
Further Subject Didactics

For students enrolled from HS 2019: The courses offered here are credited under the category «Subject Didactics and Professional Training».

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-9005-00L</td>
<td>Mentored Work Specialised Courses in the Respective Subject with an Educational Focus Food Sc.</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>G. Kaufmann, K. Koch, U. Lerch</td>
</tr>
</tbody>
</table>

**Abstract**
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

**Objective**
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

**Content**
The aim is for the students

Thematische Schwerpunkte:


Lernformen:

Lecture notes
Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

**Food Science TC - Key for Type**

| O       | Compulsory                         | E-    | Recommended, not eligible for credits |
| W+      | Eligible for credits and recommended | Z     | Courses outside the curriculum       |
| W       | Eligible for credits               | Dr    | Suitable for doctorate               |

**Key for Hours**

| V       | lecture                          | P     | practical/laboratory course         |
| G       | lecture with exercise            | A     | independent project                 |
| U       | exercise                         | D     | diploma thesis                      |
| S       | seminar                          | R     | revision course / private study     |
| K       | colloquium                       |       |                                     |

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-3103-00L</td>
<td>Food Rheology</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>P. A. Fischer</td>
</tr>
</tbody>
</table>

**Abstract**
Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

**Objective**
The course provides an introduction on the link between fluid and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

**Content**
Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (8h) and structure and rheology of complex fluids (4h).

**Lecture notes**
Notes will be handed out during the lectures.

**Literature**
Provided in the lecture notes.

| 752-2003-00L | Selected Topics in Food Technology         | W+   | 3    | 2V    | R. Stadler, C. Bolten |

**Abstract**
Part 1 of the course deals with global market trends, food technologies, food health benefits. Physical and chemical fundamental knowledge help grasp the molecular composition of food. Part 2 entails management of risks across the food supply chain. The focus is on technological solutions to mitigate hazards, as well as their management upstream.

**Objective**
The objectives of the course are for students to understand the key drivers (market and consumer trends, health benefits, sustainability, etc.) that impact innovation in a food business environment. The course also illustrates food safety and quality considerations across the whole supply chain, using concrete examples and how certain technologies assist in reducing or eliminating food safety risks.

**Content**
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

**Lecture notes**
Notes will be handed out during the lectures.

**Literature**
Provided in the lecture notes.

| 752-2314-00L | Physics of Food Colloids                   | W+   | 3    | 2V    | P. A. Fischer, R. Mezzenga |

**Abstract**
In Physics of Food Colloids the principles of colloid science will applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

**Objective**
The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

**Content**
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

**Lecture notes**
Notes will be handed out during the lectures.

**Literature**
Provided in the lecture notes.

| 752-3021-00L | Food Process Design and Optimization       | W+   | 4    | 2G    | E. J. Windhab |

**Abstract**

**Objective**
Training by case studies from research and industrial production.

**Content**
S-PRO2 scheme, reverse engineering approach, dimension analysis, Metznzer-Otto and Rieger Novack design schemes of stirred reactors for non-Newtonian fluid processing, mixing/mixing statistics, mixing characteristics, power charac-teristics, dispersing characteristics, dispersing processes in rotor/ stator and membrane devices, spray processing, extrusion processing, diverse case studies for design and scaling of processes for food structure processing

**Lecture notes**
Printed handouts (ca. 180)

**Literature**
List of ca. 30 papers and 5 books given in course

| 752-3023-00L | Process Measurements and Automation        | W+   | 3    | 2G    | E. J. Windhab |

**Abstract**
Overview on Process Automation, Information Management in processes, process data handling and analysis, In-line measurements of complex food systems, Process control schemes, Overview of sensors and sensor principles, integrated process control case studies

**Objective**
Understanding the interplay of in-line measurements of complex food properties in processes, process data handling and data analysis as well as building blocks for process control.

**Content**
Overview Process Automation, Process Control and process data management, Industrial design of automated/controlled processes, overview on sensors/sensor principles, case studies of in-line measurements and control in/of food production processes

**Lecture notes**
Printed script (120 pages, 80 figures), diverse publications

**Literature**
List of publications and books given in course

| 752-3201-00L | Emerging Thermal and Non Thermal Food Processing | W     | 3    | 2V    | A. Mathys |

**Abstract**
This course is built on the holistic approach in sustainable food processing via the consideration of the total value chain. Selected mechanical, biotechnological, thermal and non-thermal techniques for best biomass and energy use efficiency will be investigated. Focused technologies are new thermal processes, high pressure techniques, electroproportion and different radiation based sources.

**Objective**
Understanding of selected emerging food processing concepts with focus on lower process intensity for healthy and high quality food production, waste reduction as well as biomass and energy use efficiency. Updates from academia and industry around new trends in food process development

**Content**
Emerging combined processes based on mechanical, thermal and non-thermal techniques, Multi hurdle technology concept for preservation, Extreme high temperature-short time processes, high pressure techniques, electroproportion, radiation, Biorefineries based on emerging process elements, Ongoing industry initiatives

**Lecture notes**
Script will be distributed before the course via Moodle.
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by friendly food processing.


Methodology Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
</tbody>
</table>

Abstract

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective

Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Prerequisites / notice

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Literature


Prerequisites / notice

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Lecture notes

A script will be available.

Number | Title                                      | Type | ECTS | Hours   | Lecturers |
<table>
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<td>Applied Analysis of Variance and Experimental Design</td>
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<tr>
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<td>Applied Statistical Regression</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
</tbody>
</table>

Abstract

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Prerequisites / notice

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Data: 18.08.2022 12:39

Optional Subjects

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<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>752-3105-00L</td>
<td>Physiology Guided Food Structure and Process</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>E. J. Windhab, M. Devezeaux de Lavergne, B. von der Weid, T. Wooster</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td></td>
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<td></td>
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</tbody>
</table>

Abstract

A "cook-and-look" approach to process design is no longer applicable in the current environmental, nutritional and competitive constraints. The modern R&D chemical/food engineer should have a clear focus on the desired structure that needs to be achieved to design a process line or a processing equipment, coupled with in depth knowledge of the processed materials.

Objective

The objective of this course is to highlight the intimate links between human physiology and product sensory and nutritional functions. To optimize these functions, an understanding of the physiological functions that interact and encode the actions of those product structures must be well understood.

Therefore the objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures.

The students will be exposed to this interplay all along the GI tract, including taste, aroma and texture perception, swallowing mechanics and gastrointestinal digestion with an engineering or physical sciences angle.

Major in Food Quality and Safety

Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-0801-00L</td>
<td>Food Law and Legislation</td>
<td>W+</td>
<td>1 credit</td>
<td>1V</td>
<td>K. Krell Zbinden, E. Zbinden Kaessner</td>
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</table>

Abstract

Introduction to the principles of the EU and international Organisations, Principles of the Swiss food law.

Objective

Knowledge of the principles and the structure of the EU in general and in the area of food safety, overview of the relevant bilateral agreements CH-EU as well as on the most important international organisations (Codex Alimentarius and WTO) and their influence on the Swiss regulations on food safety.

Content

General introduction into the EU and in the area of food safety (regulation on food safety), legislative procedures in the EU, introduction into the relevant bilateral agreements CH-EU, introduction into international organisations (e.g. Codex Alimentarius), general principles of the Swiss food law and the most important regulations as well as the most important legal procedures, legal settlement and the duties and responsibilities of the Food control authorities.

Lecture notes

Copies of the presentations will be handed out.

Literature

Documents about Codex Alimentarius, the EU regulation as well as the Swiss food law and some regulations will be handed out.

Prerequisites / notice

Qualifications: General knowledge of the food sciences. The lecture will be held in German.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>752-1021-00L</td>
<td>Food Enzymology</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>L. Nyström, M. Erzinger</td>
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</table>

Abstract

The course covers the fundamentals of food enzymology, application of endogenous and exogenous enzymes in food processing, as well as use of enzymes in analytics.

Objective

Students can describe what enzymes are and can explain their use and functions in food and food products. Students can argue why and how enzymes are used in food processing and analysis.

Content

Enzymes in foods: the use of added enzymes in food processing, control and/or utilization of endogenous enzymes, production of enzyme preparations for food use, and chemical analysis of food components by enzymatic methods.

Lecture notes

Course contains lectures and a practical group work.

Prerequisites / notice

The lectures are supplemented with handouts.

<table>
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<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>752-4009-00L</td>
<td>Molecular Biology of Foodborne Pathogens</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Loessner, M. Schmelcher, M. Schuppler, E. Wetter Slack</td>
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</table>

Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Autumn Semester 2022
Page 1332 of 2345
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by working with microorganisms. This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. The course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Prerequisites / Notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-5103-00L Functional Microorganisms in Foods

Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefitting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:
- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Anti-microbial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

Lecture notes
Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-1301-00L Special Topics in Toxicology

Abstract
Journal-club style course involving student presentations and active discussion and critique of recent publications and modern experimental strategies. The focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester

Objective
- to stimulate student interest and provide advanced knowledge of current research in Toxicology and its related sciences
- to develop skills in critical evaluation of scientific literature, oral presentation and questioning
- to understand modern experimental techniques and research approaches relevant in toxicology

Content
The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

Literature
A selection of approximately 20 papers from recent primary scientific literature.

Prerequisites / Notice
The course is open to Masters or PhD level students.

If you would like to take "Special Topics in Toxicology", do not register at the same time for "Advanced Topics in Toxicology". It is only possible to take one, and it is only possible to take the advanced level after completing this course.

Methodology Subjects

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W+</td>
<td>5 credits</td>
<td>2+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / Notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W+</td>
<td>5 credits</td>
<td>2+1U</td>
<td>M. Dettling</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1333 of 2345
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

A script will be available.

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1988): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

752-5500-00L Applied Bioinformatics: Microbiomes

Abstract
Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Objective
Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.

Content
1. Introduction to microbiomes and microbial bioinformatics toolkit. UNIX/bash, Python, Pandas, Jupyter, git/GitHub, visualization libraries for Python.
3. Microbial diversity, function, and ecology. Molecular ecology, diversity metrics, ordination methods.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Prerequisites / notice
No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (UNIX/bash and/or Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers (students without a laptop should consult with their department’s ISG group).

All software used in the course is free and open-source. Installation instructions will be provided to students prior to the start of the course.

Optional Subjects

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>W+</td>
<td>3</td>
<td>2</td>
<td>F. Constancias, G. Brogini, A. Greppi, F. Orelli, to be announced</td>
</tr>
</tbody>
</table>

Abstract
This course will increase basic knowledge on biotechnological constructions and application of genetically modified organisms (GMO) which are used worldwide in food production systems. The course discusses health issues, the legislation frame and food safety aspects of GMO applications in agriculture, food production and consumption in Switzerland and EU-countries.

Objective
This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of GMO, especially on the molecular basis of GMO constructions with emphasis on genetically modified food in Switzerland and the EU. Criteria of rationale food safety and health assessment in agriculture and food consumption will be elaborated.
**Major in Nutrition and Health**

**Disciplinary Subjects**

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-2307-00L</td>
<td>Nutritional Aspects of Food Composition and Processing</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>B. E. Baumer, J. M. Sych</td>
</tr>
</tbody>
</table>

Abstract

Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.

Objective

- Students should be able to describe and compare the major concepts/criteria used for the evaluation of the nutritional quality of food.
- Apply these criteria when assessing the effects of selected processing technologies on nutritional quality.
- Evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods).

Content

The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.

Lecture notes

There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.

Prerequisites / notice

The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

Taught competencies

- Subject-specific Competencies: Concepts and Theories

- Method-specific Competencies: Analytical Competencies

- Personal Competencies: Critical Thinking

assessed

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
</tr>
</tbody>
</table>

Abstract

The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.
## Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
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</table>

## Abstract

- **401-0625-01L**: Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

- **401-0649-00L**: This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

## Objective

- **401-0625-01L**: Participants will be able to plan and analyze efficient experiments in the fields of natural sciences, They will gain practical experience by using the software R.

- **401-0649-00L**: The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

## Content

- **401-0625-01L**: Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

- **401-0649-00L**: The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

## Literature


## Prerequisites / notice

- **401-0625-01L**: The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

- **401-0649-00L**: The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

## Taught competencies

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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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## Taught competencies

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</thead>
<tbody>
<tr>
<td>752-5500-00L</td>
<td>Applied Bioinformatics: Microbiomes</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+2U</td>
<td>N. Bokulich</td>
</tr>
</tbody>
</table>

## Abstract

- **752-5500-00L**: Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

## Objective

- **752-5500-00L**: Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to food quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microbiomes (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.
### Optional Subjects

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>752-5103-00L</td>
<td>Functional Microorganisms in Foods</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>C. Lacroix, A. Gerinaert, A. Greppi</td>
</tr>
<tr>
<td>752-6403-00L</td>
<td>Nutrition and Performance</td>
<td>W*</td>
<td>2</td>
<td>2V</td>
<td>S. Mettler, M. B. Zimmermann</td>
</tr>
<tr>
<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>F. Constancias, G. Broggi, A. Greppi, F. Orelli</td>
</tr>
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</table>

**Functional Microorganisms in Foods**

This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

**Objective**

To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

**Content**

This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

**Lecture notes**

Copy of the power point slides from lectures will be provided.

**Prerequisites / notice**

A list of topics for group projects will be supplied, with key references for each topic.

**Nutrition-Related Physiology**

Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand.

**Objective**

Some basic knowledge in physiology is recommended for this course, which revisits important physiological topics, emphasizing their relation to nutrition. The aim is to give the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. For students with a background in medicine, pharmacy or biology, the course is useful as a review of previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance.

**Lecture notes**

Handouts for each lecture will be uploaded to Moodle every week.

**Gene Technology in Foods**

This course will discuss the use of bioinformatics and molecular methods in food processing and quality control. It will cover the use of genomics and proteomics in food safety and quality control, and will introduce students to the use of microbiology and biotechnology in food production.

**Objective**

This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of GMO, especially on the molecular basis of GMO constructions with emphasis on genetically modified food in Switzerland and the EU. Criteria of rationale food safety and health assessment in agriculture and food consumption will be elaborated.

**Literature**

This lecture requires strong basics in microbiology.
Overview on application in gene technology, the gene transfer potential of bacteria, plants and other organisms and the mostly used transgenes in food as well as on GMO used for food production and their detection technologies in food; food safety assessment of GMO food; information on the legislation in Switzerland and EU-countries

Copies of slides from lectures will be provided

Actual publications from literature will be provided

Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.

Some contents will be provided by registered students who will present as a group an actual publication.

Special Topics in Toxicology

W 2 credits

K. Hecht, F. Michailidou

Critical club style course involving student presentations and active discussion and critique of recent publications and modern experimental strategies. The focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester

-to stimulate student interest and provide advanced knowledge of current research in Toxicology and its related sciences

-to develop skills in critical evaluation of scientific literature, oral presentation and questioning

-to understand modern experimental techniques and research approaches relevant in toxicology

The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

A selection of approximately 20 papers from recent primary scientific literature.

For Masters level participants, a strict prerequisite is (a) previously taken and passed “Introduction to Toxicology” (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for "Advanced Topics in Toxicology". It is only possible to take one, and it is only possible to take the advanced level after completing this course.

Nutrient Analysis in Foods

W 3 credits

J. Rigutto

In this practical course, different meals are prepared and then analysed for nutritional content in the laboratory. The analyses comprise macronutrients and specific micronutrients, as well as polyphenols and phytic acid. Based on these results, the nutritional value of each meal is critically evaluated and discussed.

The nutritional values of the meals are discussed, as well as their relation to specific chronic diseases and iron bioavailability. Discussion is facilitated by an oral presentation with colloquium and a written report.

The practical course is accompanied by lectures on the basic principles of analytical chemistry that will be made available via Moodle. The cooking and laboratory methods will be described in a "script" which will be made available before the start of the course.

All lectures will have full notes and a recording made available via Moodle.

Students will work in groups, and will assess one group per meal.

Performance will be assessed by means of:

1) Contribution to laboratory practical work (30.01.2023 - 8.02.2023);
2) A written test on course content (via Moodle, completed by 10.02.2023);
3) A 15 min oral presentation of laboratory results in a seminar with colloquium (active discussion) (17.02.2023);
4) A 5-page written report per group (deadline 24.02.2023).

The module Public Health is compulsory for all students in the major Human Health, Nutrition and Environment.

Module Public Health

The module Public Health is compulsory for all students in the major Human Health, Nutrition and Environment.

Number  Title Type ECTS Hours Lecturers

401-0629-00L Applied Biostatistics W+ 4 credits 3G M. Tanadini

This course covers the main methods used in Biostatistics. It starts by revising Linear Models (Regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

After this course students:

- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

The module Epidemiology and prevention and public health concepts explore infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

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The focus is on primary literature, but for some parts the following text books provide good background information:

Schmid Hempel 2011 Evolutionary Parasitology
Stearms & Medzhitov 2016 Evolutionary Medicine

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence,

Lectures:

To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including

gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

2V

The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes,


Publications and class notes can be downloaded from a web page announced during the lecture.

Prerequisites / notice

The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note

that each practical takes 2 hours longer than the weekly lecture.


Abstract

This course provides a detailed understanding of

- the development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective

Obtain a detailed understanding of

- the development, activation, and differentiation of different types of T cells and their effectormechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naïve B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature

Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice

Immunology I and II recommended but not compulsory

752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loeser, M. Schmelcher, M. Schuppier, E. Wetter Slack

Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant

molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the

microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the

associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various

purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content

- Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms
  (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they
  work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What
  can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of
  bacteria in microbial pathogenicity will be highlighted, in addition to various applications of bacteriotherapy for both diagnostics and
  antimicrobial intervention.

Literature

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Prerequisites / notice

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break !

701-0263-01L Seminar in Evolutionary Ecology of Infectious Diseases W 3 credits 2G R. R. Regös, S. Bonhoeffer

Abstract

Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student

chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will

change from year to year corresponding to the progress and new results occuring in the field.

Objective

This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific

literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

Content

A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence,

resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and

fungi. Hosts will include animals, plants and humans.

Literature

Publications and class notes can be downloaded from a web page announced during the lecture.

Papers will be assigned and downloaded from a web page announced during the lecture.

Module Nutrition and Health

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease W 3 credits 2V</td>
<td>M. B. Zimmermann</td>
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</tbody>
</table>

Abstract

To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective

To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content

The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1340 of 2345
Lecturers
To be provided by the individual lecturers, at their discretion. Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website "Food and Consumer Behaviour". Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection. Lecture notes
Copy of the power point slides from lectures will be provided. Literature
A list of topics for group projects will be supplied, with key references for each topic. Prerequisites / notice
This lecture requires strong basics in microbiology.

Module Environment and Health

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-1353-00L</td>
<td>Nanostructured Materials Safety</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>P. Wick</td>
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<td></td>
<td>Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection</td>
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<td>Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials</td>
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<tr>
<td></td>
<td>Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website</td>
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Term Paper

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Only for students of the Major Human Health, Nutrition and Environment</td>
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<td></td>
<td>Writing of a review paper of scientific quality on a topic in the domain of Human Health, Nutrition and Environment based on critical evaluation of scientific literature</td>
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<td></td>
<td>Acquisition of knowledge in the field of the review paper</td>
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<td>Assessment of original literature as well as synthesis and analysis of the findings</td>
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<td>Practising of academic writing in English</td>
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<td>Giving an oral presentation with discussion on the topic of the review paper</td>
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<td>Guidelines will be handed out in the beginning.</td>
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<td>Literature will be identified based on the topic chosen.</td>
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Methodology Subjects

The courses are offered in the spring semester

Minors

Food Biotechnology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-5105-00L</td>
<td>Biotechnology of Alcoholic Beverage Production</td>
<td>W+</td>
<td>2</td>
<td>2V</td>
<td>R. Mira de Orduna Heidinger, A. Bühlmann, S. Schönemberg</td>
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<td></td>
<td>Number of participants limited to 30.</td>
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<td></td>
<td>This course introduces fundamental aspects of the production of beer and grape wine.</td>
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</tbody>
</table>
The objective of the course is to provide participating students with a sound understanding of the raw materials, microorganisms, microbial and chemical transformations and processing aspects involved in the production of beer and grape wine. Sensory aspects and product stability will also be considered.

Content
>> Introduction of alcoholic beverage production within industrial microbiology
>> Brewing
- Raw materials, and malting
- Brewhouse processes, wort production, fermentations, lagering
- Sensory aspects and diacetyl management
>> Winemaking
- Grape growing and grape processing
- Crush and pressing
- Fermentations and microbial transformations
- Fining, stabilizations, filtration and bottling
- Aroma and macromolecule chemistry, climate change
- Sensory aspects and wine faults

Lecture notes
Lecture handouts will be provided either electronically or at the beginning of lectures.

Literature
A list of learning materials will be provided with the lecture handouts.

Prerequisites / notice
Students taking 752-5105-00L require a sound knowledge of basic chemistry, biochemistry, molecular genetics, microbiology and microbial physiology.

In order to decipher the costs of tastings, a financial participation of CHF30 will be required per student.

<table>
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<tr>
<th>Course Code</th>
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<th>Type</th>
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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>F. Constancias, G. Broggini, A. Geirnaert, A. Greppi, to be announced</td>
</tr>
<tr>
<td>752-5103-00L</td>
<td>Functional Microorganisms in Foods</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Lacroix, A. Geirnaert, A. Greppi</td>
</tr>
<tr>
<td>752-1021-00L</td>
<td>Food Enzymology</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>L. Nyström, M. Erzinger</td>
</tr>
</tbody>
</table>

Lectures are supplemented with handouts.

Course prerequisites: Food Chemistry I/II and Food Analysis I/II (or equivalent)
Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

Abstract
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Exercises are an integral part of the lecture.

Prerequisites:
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Food Microbiology

Number: 752-4009-00L
Title: Molecular Biology of Foodborne Pathogens
Type: W+
ECTS: 3
Hours: 2V
Lecturers: M. Loessner, M. Schmelcher, M. Schuppler, E. Wetter Slack

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health. Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation. 

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation. 

This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products. Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation. 

This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of foods cultures and probiotics

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- Safety of foods cultures and probiotics

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- Industrial biotechnology of flavor and taste development
- Safety of foods cultures and probiotics

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- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of foods cultures and probiotics
Safety and Quality in Agri-Food Chain

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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, C. Hartmann</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
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<td></td>
<td>This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products. The course provides an overview about the following topics: Factors influencing consumer's food choice, food and health, attitudes towards new foods and food technologies, labeling and food policy issues.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<td>Students should be able to - describe and compare the major concepts /criteria used for the evaluation of the nutritional quality of food - apply these criteria when assessing the effects of selected processing technologies on nutritional quality - evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods).</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td>The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td>There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.</td>
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<tr>
<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.</td>
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<td></td>
<td><strong>Taught competencies</strong></td>
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<td><strong>Subject-specific Competencies</strong> Concepts and Theories assessed <strong>Analytical Competencies</strong> assessed <strong>Decision-making</strong> assessed <strong>Problem-solving</strong> not assessed <strong>Project Management</strong> not assessed <strong>Communication</strong> not assessed <strong>Cooperation and Teamwork</strong> not assessed <strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
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<td><strong>Method-specific Competencies</strong></td>
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<td><strong>Concepts and Theories</strong> assessed <strong>Analytical Competencies</strong> assessed <strong>Decision-making</strong> assessed <strong>Problem-solving</strong> not assessed <strong>Project Management</strong> not assessed <strong>Communication</strong> not assessed <strong>Cooperation and Teamwork</strong> not assessed <strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
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<td><strong>Personal Competencies</strong></td>
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<td></td>
<td><strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
</tr>
<tr>
<td>752-2307-00L</td>
<td>Nutritional Aspects of Food Composition and Processing</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>B. E. Baumer, J. M. Sych</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.</td>
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<td><strong>Objective</strong></td>
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<td>Students should be able to - describe and compare the major concepts /criteria used for the evaluation of the nutritional quality of food - apply these criteria when assessing the effects of selected processing technologies on nutritional quality - evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods).</td>
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<td><strong>Content</strong></td>
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<td>The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
<td></td>
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<td></td>
<td>There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.</td>
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<td><strong>Taught competencies</strong></td>
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<td><strong>Subject-specific Competencies</strong> Concepts and Theories assessed <strong>Analytical Competencies</strong> assessed <strong>Decision-making</strong> assessed <strong>Problem-solving</strong> not assessed <strong>Project Management</strong> not assessed <strong>Communication</strong> not assessed <strong>Cooperation and Teamwork</strong> not assessed <strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
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<td><strong>Method-specific Competencies</strong></td>
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<td><strong>Concepts and Theories</strong> assessed <strong>Analytical Competencies</strong> assessed <strong>Decision-making</strong> assessed <strong>Problem-solving</strong> not assessed <strong>Project Management</strong> not assessed <strong>Communication</strong> not assessed <strong>Cooperation and Teamwork</strong> not assessed <strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
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<td></td>
<td><strong>Personal Competencies</strong></td>
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<td></td>
<td><strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
</tr>
<tr>
<td>751-6001-00L</td>
<td>Forum: Livestock in the World Food System</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>S. Meese</td>
</tr>
<tr>
<td></td>
<td><strong>Number of participants limited to 20.</strong></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation. The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.</td>
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<tr>
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<td><strong>Objective</strong></td>
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<td>In the Forum &quot;Livestock in the World Food System&quot;, a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td>The Forum &quot;Livestock in the World Food System&quot; will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts: Part 1 Aspect 1 - Oral presentation: The students form small groups and are lecturers. Aspect 2 - chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions. Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style. Part 2. Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer. Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process. Introductions to both presentation forms will be given by the lecturer. Requirements for allocation of the two credit points: - oral talk with sufficient handout - delivery of the scientific writing in sufficient quality - active participation during all presentations (in case of absence there will be additional tasks) Feedback on the presentation style of a student</td>
</tr>
<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td>no script</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td>Requirements for allocation of the two credit points:</td>
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<tr>
<td></td>
<td><strong>Taught competencies</strong></td>
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<td><strong>Method-specific Competencies</strong> assessed <strong>Analytical Competencies</strong> assessed <strong>Decision-making</strong> assessed <strong>Problem-solving</strong> not assessed <strong>Project Management</strong> not assessed <strong>Communication</strong> not assessed <strong>Cooperation and Teamwork</strong> not assessed <strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
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<td></td>
<td><strong>Personal Competencies</strong></td>
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<td></td>
<td><strong>Creative Thinking</strong> not assessed <strong>Critical Thinking</strong> assessed</td>
</tr>
<tr>
<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>F. Constancias, G. Broggin, A. Greppi, F. Orelli, to be announced</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This course will increase basic knowledge on biotechnological constructions and application of genetically modified organisms (GMO) which are used worldwide in food production systems. The course discusses health issues, the legislation frame and food safety aspects of GMO applications in agriculture, food production and consumption in Switzerland and EU-countries. This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of GMO, especially on the molecular basis of GMO constructions with emphasis on genetically modified food in Switzerland and the EU. Criteria of rational food safety and health assessment in agriculture and food consumption will be elaborated.</td>
</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
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<td></td>
<td>This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of GMO, especially on the molecular basis of GMO constructions with emphasis on genetically modified food in Switzerland and the EU. Criteria of rational food safety and health assessment in agriculture and food consumption will be elaborated.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td>Overview on application in gene technology, the gene transfer potential of bacteria, plants and other organisms and the mostly used transgenes in food as well as on GMO used for food production and their detection technologies in food; food safety assessment of GMO food; information on the legislation in Switzerland and EU-countries.</td>
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</table>
**Food Physics**

**Number**  
752-3103-00L

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Rheology I</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>P. A. Fischer</td>
</tr>
</tbody>
</table>

**Abstract**  
Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

**Objective**  
The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

**Content**  
Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

**Lecture notes**  
Notes will be handed out during the lectures.

**Literature**  
Provided in the lecture notes.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-2314-00L</td>
<td>Physics of Food Colloids</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>P. A. Fischer, R. Mezzenga</td>
</tr>
</tbody>
</table>

**Abstract**  
In Physics of Food Colloids the principles of colloid science will be applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

**Objective**  
The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

**Content**  
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

**Lecture notes**  
Notes will be handed out during the lectures.

**Literature**  
Provided in the lecture notes.

**Food Toxicology**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-1301-00L</td>
<td>Special Topics in Toxicology</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>K. Hecht, F. Michailidou</td>
</tr>
</tbody>
</table>

**Abstract**  
Journal-club style course involving student presentations and active discussion and critique of recent publications and modern experimental strategies. The focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester

**Objective**  
- to stimulate student interest and provide advanced knowledge of current research in Toxicology and its related sciences  
- to develop skills in critical evaluation of scientific literature, oral presentation and questioning  
- to understand modern experimental techniques and research approaches relevant to toxicology

**Content**  
The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

**Literature**  
A selection of approximately 20 papers from recent primary scientific literature.

**Prerequisites / notice**  
The course is open to Masters or PhD level students.

For Masters level participants, a strict prerequisite is (a) previously taken and passed “Introduction to Toxicology” (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for “Advanced Topics in Toxicology”. It is only possible to take one, and it is only possible to take the advanced level after completing this course.

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-1302-00L</td>
<td>Advanced Topics in Toxicology</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>F. Michailidou, S. J. Sturia</td>
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</tbody>
</table>

**Abstract**  
Journal-club style course that involves student presentations of selected topics in Toxicology on the basis of current research and review papers.
The goals are to stimulate student interest and provide advanced knowledge of current research in the interdisciplinary area of Food and Nutrition Toxicology and its related sciences. The student should develop skills in the critical evaluation of scientific literature, oral presentation and questioning, and understanding modern experimental techniques in Molecular Toxicology.

The journal-club style course involves student presentations of recent publications. The primary focus is on chemical and biochemical aspects of selected topics in Toxicology. Participants are generally masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Pharmaceutical Sciences, etc.), and strong knowledge of organic chemistry and biochemistry are prerequisite. Selected course topics change every semester.

Participants are required to have completed previously "Special Topics in Toxicology" (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for "Advanced Topics in Toxicology" until after you have completed "Special Topics in Toxicology"

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-4009-00L</td>
<td>Molecular Biology of Foodborne Pathogens</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Loesanner, M. Schmelcher, M. Schuppler, E. Wetter Slack</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.</td>
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<tr>
<td>Objective</td>
<td>Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.</td>
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<tr>
<td>Content</td>
<td>Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? Is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.</td>
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<tr>
<td>Lecture notes/Literature</td>
<td>Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students. Recommendations will be given in the first lecture</td>
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<tr>
<td>Prerequisites/notice</td>
<td>Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break !</td>
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<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
</tr>
<tr>
<td>Abstract</td>
<td>The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development of preventive and treatment interventions and to improved population health.</td>
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<tr>
<td>Objective</td>
<td>The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.</td>
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<tr>
<td>Content</td>
<td>The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.</td>
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<td>Taught competencies</td>
<td>Concepts and Theories assessed</td>
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<td>Analytical Competencies assessed</td>
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<td>Decision-making assessed</td>
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<td>Problem-solving not assessed</td>
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<td>Project Management not assessed</td>
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<td>Social Competencies</td>
<td>Communication not assessed</td>
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<td></td>
<td>Cooperation and Teamwork not assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking assessed</td>
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<tr>
<td>376-1353-00L</td>
<td>Nanostructured Materials Safety</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>P. Wick</td>
</tr>
<tr>
<td>Abstract</td>
<td>Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.</td>
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<tr>
<td>Objective</td>
<td>Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website</td>
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<tr>
<td>Prerequisites/notice</td>
<td>course “Introduction to Toxicology”</td>
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**Electives**

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-0005-00L</td>
<td>Colloquium in Food and Nutrition Science</td>
<td>W</td>
<td>1</td>
<td>2K</td>
<td>S. J. Sturla</td>
</tr>
<tr>
<td>Abstract</td>
<td>Participation in weekly seminars on a variety of topics including Food Microbiology, Food Toxicology, Food Biochemistry, Food Processing, Consumer Behavior, Food Technology, and Food Materials and Technology, and oral presentation of a selected published study in one of these areas inspired by participation in the seminars.</td>
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<tr>
<td>Objective</td>
<td>The objectives are to become familiar with and stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the semester presentations.</td>
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**Master’s Thesis**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-0230-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Objective</td>
<td>Only students who fulfill the following criteria are allowed to begin with their master thesis: a. successful completion of the bachelor programme; b. fulfilling of any additional requirements necessary to gain admission to the master programme; c. has acquired at least 30 CPs in the master programme.</td>
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<tr>
<td>Notice</td>
<td>The topic of the thesis and - if they are not Professors of D-HEST - the examiner and the co-examiner have to be approved by the D-HEST Department Conference.</td>
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The Master thesis completes the master programme and is an independent scientific project. Generally, the topic is selected from the specific field of the major. It is supervised by a professor/Privatdozents at D-HEST or D-USYS, Agricultural Sciences.

The Master Thesis must demonstrate the student's ability to independent, structured and scientific working.

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-1000-AAL</td>
<td>Food Chemistry I</td>
<td>E-</td>
<td>3</td>
<td>6R</td>
<td>L. Nyström</td>
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<td>To familiarise with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.</td>
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<td>Descriptive chemistry of food constituents (proteins, lipids, carbohydrates, plant phenolics, flavour compounds). Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (e.g. lipid oxidation, Maillard reaction, enzymatic browning). Links to food analysis, food processing, and nutrition.</td>
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<td>Lecture notes</td>
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<td>The lectures are supplemented with handouts.</td>
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<tr>
<td>752-1101-AAL</td>
<td>Food Analysis I</td>
<td>E-</td>
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<td>6R</td>
<td>L. Nyström</td>
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<td>To understand the basic principles of analytical chemistry. To get acquainted with the principles and applications of important routine methods of instrumental food analysis (UV/VIS, IR, AAS, GC, HPLC).</td>
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<tr>
<td>752-3000-AAL</td>
<td>Food Process Engineering I</td>
<td>E-</td>
<td>4</td>
<td>9R</td>
<td>P. A. Fischer</td>
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<td>To procure students with the basic physics of food process engineering, especially with the mechanical futures of food systems, i.e. basic principles of engineering mechanics, of thermodynamics, fluid dynamics and of dimension analyses for process design and Non-Newtonian fluid mechanics.</td>
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<tr>
<td>752-6001-AAL</td>
<td>Introduction to Nutritional Science</td>
<td>E-</td>
<td>3</td>
<td>6R</td>
<td>M. B. Zimmermann, C. Wolfrum</td>
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<td>This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.</td>
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<td>To introduce the students to the both macro- and micronutrients in relation to food and metabolism.</td>
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<td>This is a self-study course. The course is devided into two parts: micronutrients are given by and macronutrients a. The micronutrients include fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. The part on macronutrients introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism.</td>
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<td></td>
<td>Lecture notes</td>
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<td>A reading list will be provided to the students detailing chapters and lecture slides to be studied</td>
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<tr>
<td>551-0001-AAL</td>
<td>General Biology I</td>
<td>E-</td>
<td>3</td>
<td>6R</td>
<td>U. Sauer, O. Y. Martin, A. Widmer</td>
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<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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</table>
Abstract
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

Objective
The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Content
The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogentic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular&seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

Lecture notes
No script

Literature

Prerequisites / notice
This is a virtual self-study lecture for non-german speakers of the "Allgemeine Biology I (551-0001-00L) lecture. The exam will be written jointly with the participants of this lecture.

Example exam questions will be discussed during the lectures, and old exam questions are kept by the various student organisations. If necessary, please contact Prof. Uwe Sauer (sauer@ethz.ch) for details regarding the exam.

406-0063-AAL
Physics II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content
Book:

Chapters:

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003, Fr. 77.-

406-0503-AAL
Stochastics (Probability and Statistics)
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".
Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student’s t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435
  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

752-4001-AAL Microbiology E- 2 credits 4R M. Ackermann
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Self-study course in microbiology.

Objective
Teaching of basic knowledge in microbiology.

Content
This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature
This self-study course is based on the book ‘Brock, Biology of Microorganisms’.

701-0071-AAL Mathematics III: Systems Analysis E- 4 credits 9R R. Knutti, H. Wernli
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content
Introduction to principles of models; one-dimensional linear box models; multi-dimensional linear box models; nonlinear box models; models in space and time

Lecture notes
Teaching material: book (see literature).

Literature


752-4005-AAL Food Microbiology I E- 3 credits 6R M. Loessner
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Objective
The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms. The focus of this first part of the two part lecture (Food Micro II is offered in the FS) will be on the organisms, but also on the factors which determine spoilage and foodborne disease.
Content

1. History of Food Microbiology
   1.1. Short synopsis of foodborne microorganisms
   1.2. Spoilage of Foods
   1.3. Foodborne Disease
   1.4. Food Preservation
   1.5. VIP's of Food Microbiology
2. Overview of Microorganisms in Foods
   2.1 Origin of foodborne Microorganisms
   2.2. Bacteria
   2.3. Yeasts
   2.4. Molds
3. Microbial Spoilage of Foods
   3.1. Intrinsic and Extrinsic Parameters
   3.2. Meats, Seafoods, Eggs
   3.3. Milk and Milk Products
   3.4. Vegetable and Fruit Products
   3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
   3.6. Drinks and Canned Foods
4. Foodborne Disease
   4.1. Significance and Transmission of Foodborne pathogens
   4.2. Staphylococcus aureus
   4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
   4.4. Listeria monocytogenes
   4.5. Salmonella, Shigella, Escherichia coli
   4.6. Vibrio, Yersinia, Campylobacter
   4.7. Brucella, Mycobacterium
   4.8. Parasites
   4.9. Viruses and Bacteriophages
   4.10. Mycotoxins
   4.11. Bioactive Amines
   4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

551-0003-AAL General Biology I+II E- 7 credits 13R U. Sauer, K. Bomblies, O. Y. Martin, A. Widmer

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Biology I: Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

General Biology II: Molecular biology approach to teach the basic principles of biochemistry, cell biology, cgenetics, evolutionary biology and form and function of vascular plants.

Objective
General Biology I: The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

General Biology II: The understanding basic concepts of biology: the hierarchy of the structural levels of biological organisation, with particular emphasis on the cell and its molecular functions, the fundamentals of metabolism and molecular genetics, as well as form and function of vascular plants.
General Biology I:
General Biology I focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogenetic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
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29 Diversity of Life Nonvascular&seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

General Biology II: The structure and function of biomacromolecules; basics of metabolism; tour of the cell; membrane structure and function; basic energetics of cellular processes; respiration, photosynthesis; cell cycle, from gene to protein; structure and growth of vascular plants, resource acquisition and transport, soil and plant nutrition.

Specifically the following Campbell chapters will be covered:
3 Biochemistry Chemistry of water
4 Biochemistry Carbon: the basis of molecular diversity
5 Biochemistry Biological macromolecules and lipids
7 Cell biology Cell structure and function
8 Cell biology Cell membranes
10 Cell biology Respiration: introduction to metabolism
10 Cell biology Cell respiration
11 Cell biology Photosynthetic processes
16 Genetics Nucleic acids and inheritance
17 Genetics Expression of genes
18 Genetics Control of gene expression
19 Genetics DNA Technology
35 Plant structure&function Plant Structure and Growth
36 Plant structure&function Transport in vascular plants
37 Plant structure&function Plant nutrition
38 Plant structure&function Reproduction of flowering plants
39 Plant structure&function Plants signal and behavior

Lecture notes
No script

Literature

Prerequisites / notice
Basic general and organic chemistry

This is a virtual self-study lecture for non-German speakers of the "Allgemeine Biology I (551-0001-00L)" and "Allgemeine Biology II (551-0002-00L)" lectures. The exam will be written jointly with the participants of this lecture.

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.

Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

Objective
Based on the biology and chemistry courses in the 1. and 2. semester more detailed biochemical knowledge about enzymology, membrane biochemistry, and central metabolism will be presented.

Content
Program
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Carbohydrates, structure of DNA
Lipids and biological membranes
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis
The citric acid cycle
Oxidative phosphorylation
Fatty acid metabolism

Lecture notes

Literature

Prerequisites / notice
Basic knowledge in biology and chemistry is a precondition.
Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies not assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving not assessed
Project Management not assessed
Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management assessed

Physiology and Anatomy II
752-6306-AAL E- 3 credits 6R D. Burdakov, M. Ristow

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Imparts a basic understanding of physiology and anatomy in man, focusing on the close interrelations between morphology and function of the human organism. This is fostered by discussing all subjects from a functional point of view. A major topic of the lecture is food intake and digestion with its correlated endocrine and metabolic processes.

Objective
After this course the students are able to understand basic principles of systems physiology and the mechanisms of the function of the major organ systems.

Consumer Behaviour I
752-2120-AAL E- 2 credits 4R M. Siegrist, A. Bearth, A. Berthold

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Objective
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Food Science Master - Key for Type

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<th>Key for Type</th>
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<td>Courses outside the curriculum</td>
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<td>Eligible for credits</td>
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Key for Hours

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<tr>
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<td>practice/laboratory course</td>
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<td>independent project</td>
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ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Food Science Bachelor  
1. Semester  
First Year Examinations

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<td>Chemistry I</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel</td>
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Abstract  
General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

Objective  
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content  
1. Stoichiometry  
Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.

2. Atoms  
Elementary particles and atoms. Electron configuration of the elements. Periodic system.


4. Basics of chemical thermodynamics  
System and surroundings. Description of state and change of state of chemical systems.

5. First law of thermodynamics  

6. Second law of thermodynamics  
Entropy. Change of entropy in chemical systems and universe. Reaction entropy.

7. Gibbs energy and chemical potential.  

8. Chemical equilibrium  
Law of mass action. Reaction quotient and equilibrium constant. Phase transition equilibrium.

9. Acids and bases  

10. Dissolution and precipitation.  
Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes  
Online-Skript mit durchgerechneten Beispielen.

Literature  

Weiterführende Literatur:  


401-0251-00L Mathematics I  
O 6 credits 4V+2U A. Cannas da Silva

Abstract  
This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Objective  
Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.
The students are able to explain important properties of the three environmental systems, to discuss critical drivers, trends and conflicts of

1. Single-Variable Calculus:
   - Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

2. Linear Algebra and Complex Numbers:

3. Ordinary Differential Equations:
   - separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

Unterlagen, Vorlesungsfolien und relevante Literatur sind in Moddle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils

This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research.

The lecture provides a science-based exploration of environmental aspects from three research fields: earth, climate, and health sciences.

No script

551-0001-00L General Biology I O 3 credits 3V U. Sauer, O. Y. Martin, A. Widmer

Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.

- Einfluss von Umweltfaktoren (Temperatur, Strahlung, Wasser, Nährstoffe etc.) auf Organismen; Anpassung an bestimmte Umweltbedingungen
- Populationsdynamik: Ursachen, Beschreibung, Vorhersagen und Regulierung
- Interaktionen zwischen Arten (Konkurrenz, Koexistenz, Prädation, Parasitismus, Nahrungsnetze)
- Lebensgemeinschaften: Struktur, Stabilität, Sukzession
- Ökosysteme: Kompartimente, Stoff- und Energieflusse
- Biodiversität: Variation, Ursachen, Gefährdung und Erhaltung
- Aktuelle Naturschutzprobleme und -massnahmen
- Evolutionäre Ökologie: Methodik, Spezialisierung, Koevolution

Lecture notes

- Untergaben, Vorlesungsfolien und relevante Literatur sind in Moddle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils spätestens am Freitagmorgen zur Verfügung.

Literature


The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.

- Aquatische Ökologie:
  - Lampert & Sommer 1999. Limnökologie. Thieme. 2. Aufl., ca. Fr. 55.-
  - Bohle 1995. Limnische Systeme. Springer, ca. Fr. 50.-

- Naturschutzbiologie:
Content
The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of raw materials and fossil fuels, climate change and its impacts on man and environment, and the spread and control of infectious diseases in the human population and agricultural systems.

Lecture notes
Slides are provided by instructors and are accessible via moodle.

751-0013-00L World Food System

Abstract
Knowledge about the World Food System will be provided, based on case studies along food value chains in countries with various development stages and dependent on multiple boundary conditions. This shall generate profound understanding of the associated global challenges especially food scarcity, suboptimal diet and nutrition, food quality and safety as well as effects on the environment.

Objective
Attending this course, the students will recognize the elements of the World Food System (WFS) approach and the problems it this supposed to treat. They will especially comprehend the four pillars of global food security, namely (I) food availability (including sustainable production and processing), (II) access to food (physical and monetary), (III) food use (including quality and safety as well as the impact on human health and well being) and (IV) resilience to the boundary conditions (environmental, economic and political). This insight will make them aware of the global driving forces behind our ETH research on food security and is expected to alleviate motivation and understanding for the association of subsequent specific courses within a general context. The course equivalently implements agricultural and food sciences, thus supporting the interdisciplinary view on the WFS scope.

Content
Case studies on certain foods of plant and animal origin serve to demonstrate the entire food value chain from the production of raw material to processed food and its consumer relevant property functions. In doing so, important corresponding aspects for developed, emerging and developing countries are demonstrated, by use of engineering as well as natural and social science approaches.

Lecture notes
Handouts and links are provided online.

Literature
Information on books and other literature references is communicated during the course.

Prerequisites
The course shall particularly elucidate the cross section of Agro- and Food Sciences in the context of important global problems to be solved. Furthermore the students in the first year of studies shall be given some insight and outlook supporting the development of their views and interests in agricultural and food sciences further.

The course is part of the block exam after the first study year. Paper copies can be used ("Open Book") during the on-line exam, but no other means are not allowed. The course is mainly taught in German, single might be in English.

351-1158-00L Principles of Economics

Abstract
This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

Objective
After successful completion of the course you will be able to:
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Content
Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

Lecture notes
no script available.

Literature

Prerequisites
Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Taught competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Critical Thinking

Assessment
- Evaluate economic measures.
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0839-00L</td>
<td>Informatics</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>L. E. Fässler, M. Dahinden</td>
</tr>
</tbody>
</table>

Objective
Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists and tables and with relational databases, introduction to programming.

The students learn to:
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.
ECTS
A thorough study of all script materials is requested before the course starts.
not assessed

A. Vaterlaus


6P
This course is intended to provide an overview of experimental chemical methods. The classification and analysis of natural and artificial compounds is a key subject of this course. The synthesis of simple inorganic complexes or organic molecules is practised. Furthermore, the preparation and handling of environmentally relevant gaseous species like carbon dioxide or nitrogen oxides is a central subject of the Praktikum.

751-0801-00L
Fundamentals of Microscopy and Plant Biology

3. Semester

Lab: 18.08.2022 12:39
Autumn Semester 2022

Lecture notes
All materials for the lecture are available at www.evim.ethz.ch

Prerequisites / notice
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

Taught competencies

Subject-specific Competencies
Techniques and Technologies
not assessed
Analytical Competencies
not assessed
Decision-making
not assessed
Media and Digital Technologies
not assessed
Problem-solving
not assessed
Project Management
not assessed

Social Competencies
Communication
not assessed

Personal Competencies
Adaptability and Flexibility
not assessed
Creative Thinking
not assessed
Critical Thinking
not assessed
Self-awareness and Self-reflection
not assessed
Self-direction and Self-management
not assessed

Lecture notes
Handouts

Literature
For further reading (not obligatory):
Gerhard Wanner: Mikroskopisch-Botanisches Praktikum, Georg Thieme Verlag, Stuttgart.

Prerequisites / notice
Groups of a maximum of 30 students.

529-0030-00L
Laboratory Course: Elementary Chemical Techniques
This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g. investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

5 credits
6P
A. de Mello, F. Jenny, M. H. Schroth

Abstract

Objective

Content

Lecture notes
The script will be published on the web.
Details will be provided on the first day of the semester.

Literature
A thorough study of all script materials is requested before the course starts.

Prerequisites / notice

Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html

3. Semester

Basic Courses II

 Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0063-00L</td>
<td>Physics II</td>
<td>O</td>
<td>5 credits</td>
<td>3V+1U</td>
<td>A. Vaterlaus</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the concepts and tools in Physics, with the help of demonstration experiments. The Chapters treated are Electromagnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena. Whenever possible, examples relevant to the students' main field of study are given.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.

Lecture notes
A script will be distributed
### Mathematics III: Systems Analysis

**Course Code:** 701-0071-00L  
**Credits:** 4  
**Hours:** 2V+1U  
**Instructors:** C. Brunner, R. Knutti, S. Schemm, H. Wernli

**Abstract**  
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

**Objective**  
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

**Content**  
https://iac.ethz.ch/edu/courses/bachelor/vorbereitung/systemanalyse.html

**Lecture notes**  
Overhead slides will be made available through the course website.

**Literature**  

### Microbiology

**Course Code:** 752-4001-00L  
**Credits:** 2  
**Hours:** 2V  
**Instructors:** M. Ackermann, M. Schuppler, J. Vorholt-Zambelli

**Abstract**  
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

**Objective**  
Teaching of basic knowledge in microbiology.

**Content**  

**Lecture notes**  
Wird von den jeweiligen Dozenten ausgegeben.

**Literature**  
Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

### Biochemistry

**Course Code:** 752-0100-00L  
**Credits:** 2  
**Hours:** 2V  
**Instructors:** C. Frei

**Abstract**  
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo. Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

**Objective**  
Students are able to understand  
- the structure and function of biological macromolecules  
- the kinetic bases of enzyme reactions  
- thermodynamic and mechanistic basics of relevant metabolic processes  
Students are able to describe the relevant metabolic reactions in detail

**Content**  
Program  
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry  
Structure and function of proteins  
Carbohydrates  
Lipids an biological membranes  
Enzymes and enzyme kinetics  
Catalytic strategies  
Metabolism: Basic concepts and design. Repetition of basic thermodynamics  
Glycolysis, fermentation  
The citric acid cycle  
Oxidative phosphorylation  
Fatty acid metabolism

**Lecture notes**  
Horton et al. (Pearson) serves as lecture notes.

**Prerequisites / notice**  
Basic knowledge in biology and chemistry is a prerequisite.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<table>
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<tr>
<th>Social Competencies</th>
<th>Communication</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
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</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0225-00L</td>
<td>Organic Chemistry</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>K. McNeill</td>
</tr>
</tbody>
</table>

#### Abstract


#### Objective

This course builds on General Chemistry I and II. The students will learn the basic reaction mechanisms in organic chemistry. They will be able to understand and formulate simple organic reactions.

#### Content

Descriptive chemistry of functional groups (alkyl halides, aikenes, aromatic systems, carbonyls). Reaction mechanisms (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution). NMR spectroscopy.

#### Literature

Carsten Schmuck, Basisbuch Organische Chemie, Pearson

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**Additional Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0000-02L</td>
<td>Laboratory Course in Physics for Students in Food Sciences</td>
<td>O</td>
<td>2</td>
<td>4P</td>
<td>A. Biland, A. Müller</td>
</tr>
</tbody>
</table>

*Enrollment is only possible under https://www.lehrbetrieb.ethz.ch/laborpraktika.*
Basics of Food Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-1000-00L</td>
<td>Food Chemistry I</td>
<td>W+</td>
<td>3</td>
<td>2V</td>
<td>L. Nyström, S. Boulos, M. Erzinger</td>
</tr>
</tbody>
</table>

Abstract
To familiarise with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

Objective
Recognize chemical structures of the main ingredients and be able to draw them themselves
Be able to recognize functional groups and assess their properties
Understand chemical reactions and be able to estimate their influence on the quality of a food product
Being able to explain the Maillard reaction and lipid oxidation

Content
Descriptive chemistry of food constituents (proteins, lipids, carbohydrates, plant phenolics, flavour compounds).
Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (e.g. lipid oxidation, Maillard reaction, enzymatic browning).
Links to food analysis, food processing, and nutrition.

Topics:
- Structure, properties, reactivity of food ingredients
- Focus: Main ingredients (carbohydrates, proteins, lipids)
- Influence of chemical reactions on food quality
- Introduction Maillard, lipid oxidation
- Selected (possibly changing) food chemistry topics (e.g. baking, milk, flavor, alcoholic beverages, bioactive substances, etc.)

Lecture notes
The lectures Food Chemistry I and Food Chemistry II constitute a unit.

Literature

Basics of Food Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-5001-00L</td>
<td>Food Biotechnology</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>C. Lacroix, F. Constancias, B. Pugin</td>
</tr>
</tbody>
</table>

Abstract
Basic information for understanding biotechnology applied to food processing will be presented. This will include a presentation of the physiology of important productive microorganisms used in food fermentations; microbial and fermentation kinetics, and design and operation of fermentation processes and bioreactors; and application of modern molecular tools for food biotechnology.

Objective
The main goal for this course is to provide students with basic information for understanding biotechnology applied to food processing. For the students, the aim will be:
- To understand the important role of microbial physiology and molecular tools for food biotechnology;
- To understand basic principles of fermentation biotechnology, with particular emphasis on metabolism and kinetics for food applications.
Biotechnology has been defined as any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses. In this course, basic knowledge for understanding biotechnology as applied to food processing will be presented. This course builds on the application of principles learned from other basic courses in the Bachelor program, especially microbiology and microbial metabolism, molecular biology, biochemistry, physics and engineering. Students will learn about the physiology of important productive microorganisms (lactic acid bacteria, bifidobacteria, propionibacteria and fungi) used in food fermentations, closely related to applications in biotechnology. Microbial and fermentation kinetics, and design and operation of fermentations and bioreactors used for both research and industrial scale production of traditional foods and modern food ingredients will be presented. This part will be illustrated by examples of food fermentation processes, representative of specific challenges. Finally, the application of modern molecular tools to food biotechnology will be discussed.

A list of references will be given at the beginning of the course for the different topics presented during the course.

### Food Science General Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

Introduction into structural and functional aspects of the immune system.

**Abstract**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

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**Content**

**Abstract**

This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

**Objective**

To introduce the students to the both macro- and micronutrients in relation to food and metabolism.

**Content**

The course is divided into two parts. The lectures on micronutrients are given by Prof. Zimmermann and the lectures on macronutrients are given by Prof. Wolfrum. Prof. Zimmermann discusses the micronutrients, including fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. Prof. Wolfrum introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeoregulation are emphasized.

**Lecture notes**

There is no script. Powerpoint presentations will be made available.

**Literature**

Elmadfa I & Leitzmann C: Ernährung des Menschen. UTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004


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**Food Science General Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-4005-00L</td>
<td>Food Microbiology I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Loessner</td>
</tr>
</tbody>
</table>

Introduction into structural and functional aspects of the immune system.

**Abstract**

This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

**Objective**

The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

The focus of this first part of the two part lecture (Food Micro II is offered in the FS) will be on the organisms, but also on the factors which determine spoilage and foodborne disease.

**Content**

1. History of Food Microbiology

   1.1. Short synopsis of foodborne microorganisms

   1.2. Spoilage of Foods

   1.3. Foodborne Disease

   1.4. Food Preservation

   1.5. VIPs of Food Microbiology

   2. Overview of Microorganisms in Foods

   2.1 Origin of foodborne Microorganisms

   2.2. Bacteria

   2.3. Yeasts

   2.4. Molds

   3. Microbial Spoilage of Foods

   3.1. Intrinsic and Extrinsic Parameters

   3.2. Meats, Seafoods, Eggs

   3.3. Milk and Milk Products

   3.4. Vegetable and Fruit Products

   3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)

   3.6. Drinks and Canned Foods

   4. Foodborne Disease

   4.1. Significance and Transmission of Foodborne pathogens

   4.2. Staphylococcus aureus

   4.3. Gram-positive Sporeformers (Bacillus & Clostridium)

   4.4. Listeria monocytogenes

   4.5. Salmonella, Shigella, Escherichia coli

   4.6. Vibrio, Yersinia, Campylobacter

   4.7. Brucella, Mycobacterium

   4.8. Parasites

   4.9. Viruses and Bacteriophages

   4.10. Mycotoxins

   4.11. Bioactive Amines

   4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

**Lecture notes**

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

**Literature**

Recommendations will be given in the first lecture.
Training in mechanical unit operations and understanding of the related impact on food structure and properties.

Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

To get acquainted with the principles and applications of mass spectrometry in food analytics.

Selected (possibly changing) food chemistry topics (e.g. sweeteners, polysaccharides, from olive to margarine, etc.)

The lectures Food Chemistry I and Food Chemistry II constitute a unit.

The lectures Food Chemistry I and Food Chemistry II constitute a unit.

To familiarize with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

Recognize chemical structures of the main ingredients and be able to draw them themselves

Understand foods as complex systems and be able to make connections between chemical structures, chemical reactions and their influence on quality.

Recognize chemical reactions of lipid oxidation, Maillard reaction and enzymatic reactions and be able to formulate them themselves.

Descriptive chemistry of food constituents (proteins, lipids, carbohydrates, plant phenolics, flavour compounds).

Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (e.g. lipid oxidation, Maillard reaction, enzymatic browning).

Links to food analysis, food processing, and nutrition.

Food Analysis II

W+ 3 credits 2V T. Gude

Abstract
To get acquainted with the principles and applications of mass spectrometry in food analytics.

Get to know mass spectrometry in food analytics.

Content
Main focus: Mass spectrometry, applications of mass spectrometry (MS).

Lecture notes
The lectures are supplemented with handouts.

Food Process Engineering II

W+ 3 credits 3G E. J. Windhab

Abstract
To procure students with the basics of mechanical process engineering with main focus on mechanical unit operations used in the food industry.

Objective
Training in mechanical unit operations and understanding of the related impact on food structure and properties.

Content
Darstellung von Partikelgrößenverteilungen, Trennen, Zerkleinern, Agglomerieren, Beschreibung von Haufwerken, Haftkräfte, Kapillarphänomene, Sedimentation, Fest Flüssig Trennung

Es werden Übungen durchgeführt

Lecture notes
Script (ca. 100 pages, 80 figures), Lecturing slides

Literature
- F. Löffler, Grundlagen der mechanischen Verfahrenstechnik
Handouts for each topic will be made available on Moodle.

**Experimental Food Microbiology**

**ECTS** 4 credits

Imparts an advanced understanding of physiology, focusing on the link between nutrition and function of the mammalian organism. This is fostered by discussing all subjects from a viewpoint of health and disease. A major topic of the lectures is the link between nutrition and brain function, including mental health and neurodegenerative disorders.

**Objective**

At the end of the course, the students understand the biological and nutritional underpinnings of physiology with specific examples relating to brain functions.

**Prerequisites / notice**

A list with possible electives will be published separately.

**References**

- Süssmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)
- "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- "Lebensmittel-Mikrobiologie I" (752-4005-00L).
- "Food Technology".

**Number of participants limited to 48.**

**Food Technology Laboratory Course**

**ECTS** 2 credits

Prerequisite: Attendance of the course 752-2001-00L "Food Technology".

**Abstract**

Practical laboratory work on pilot plant scale on important processes for selected foods from the raw material to the final product. Evaluation of food quality.

**Objective**

Know how and handling of the production from selected manufacturing processes to the preservation of food. Understanding the effects of important parameters to the preservation of food including the evaluation of the raw material and the intermediate as well as final products; Analyzing the effects with defined manufacturing processes on the quality of the final products; Evaluation of scientific and non-scientific information and sources.

**Content**

This practical course contains different experimental blocks:

- Production of sterile canned goods, determination of sterilization conditions (obligation for all studying)
- Production of long paste goods (humidity, drying process and Characteristic)
- Production and processing of meat-loaf (employment of nitrite salts and their effect)
- Production of potato flakes (Characteristic of the ingredients among other things content of strength and drying process)
- Production of Tofu (from the soy bean to finished Tofu)
- Hot extruding of corn semolina
- Characteristic of wheat flour and production of bread (paste preparing/computations and various analyses)

**Lecture notes**

All information and the program will be sent to enrolled students prior to the start of the laboratory course by e-mail. The scripts for this course on the page of the course catalogue in learning materials are available online and can be viewed after login.

**Literature**

References are given in the manuscript.

**Prerequisites / notice**

Prerequisite is the participation in the course 752-2001-00L Food Technology.
### Basic Understanding of Therapeutic Agents

- **Objective:** Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid.

- **Content:**
  - Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

- **Lecture notes:**
  - Copies of the slides will be made available for download before each lecture.

- **Literature:**
  - Will be provided in parts before each individual lecture.

- **Prerequisites:**
  - Basic knowledge of economics

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### 327-1221-00L

**Title:** Biological and Bio-Inspired Materials

**Abstract:** The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials.

**Objective:**
- The course first offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials.
- Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.

**Content:**
- This course is structured in 3 blocks:
  - Block (I): Fundamentals of engineering in biological materials
  - Block (II): Replicating biological design principles in synthetic materials
  - Block (III): Bio-inspired design and systems

**Lecture notes**
- Copies of the slides will be made available for download before each lecture.

**Literature**

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Functional biological and bio-inspired materials</td>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
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<td></td>
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<td>Negotiation</td>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

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### 535-0230-00L

**Title:** Medicinal Chemistry I

**Abstract:** The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

**Objective:** Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

**Content:**
- Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

**Lecture notes**
- Will be provided in parts before each individual lecture.

**Literature**

**Prerequisites / notice**
- Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.
- Attendance of Medicinal Chemistry II in the spring semester.

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### 851-0626-01L

**Title:** International Aid and Development

**Abstract:**
- The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.

**Objective:**
- Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid.
- Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.

**Content:**
- Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

**Literature**
- Articles and book abstracts will be uploaded to a course website.
Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution.

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and

Reading materials and slides will be available via Moodle.

The students shall obtain the following competence:

- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall understand the legal aspects connected to an entrepreneurial activity and suggest possible solutions.

Particularly suitable for students of D-ITET, D-USYS

The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project.

Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.
Environmental Management

An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

Overview on environmental management and environmental management systems, general methods and principles.

Introduction to environmental management / environmental management systems, energy and material flows; economical and ecological problems in industry; characterisation of an enterprise (incl. management handbook); structur and contents of an environmental management system; overview on the ISO 14001 ff. series; methods for environmental evaluation and assessment; integrated management systems; planning methodology and life-cycle-design design; planning exampl

Information about environmental management and environmental management systems will be provided by a CD or mail.

Lecture notes

Prerequisites / notice

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Research Ethics

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Participants of the course Research Ethics will

• Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
• Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

I. Introduction to Moral Reasoning

1. Ethics - the basics
   1.1 What ethics is not... 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
   2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
   3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
   1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
   2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
   3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities

1. Research involving human subjects
   1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity

2. Social responsibility
   2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
   3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Number of participants limited to 40
Students . . .

After completing this course:

1. Students can explain the importance of supply chain management for a firm's strategy and success.
2. Students are able to apply the tools and methods used to optimize a supply chain structure.
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings.
4. Students can describe and evaluate fundamental logistics and supply chain concepts.
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy.
6. Students are familiar with current developments and trends in supply chain practices.

The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms competitive strategies and marketing priorities.

Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains ought to be aligned with and support the achievement of the firm's corporate, business, and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains.

Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain's role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management, and transportation. At the same time, supply chain management is inevitable for effective and efficient planning and operation of business activities. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge. The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

The course material will be made available for download on Moodle:

https://moodle-app2.let.ethz.ch/course/view.php?id=17834

All organizational matters will be handled by the teaching assistant Christian Wagner (cwagner@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

The following textbook is recommended:

The following textbook is supplementary:

Students should install MS Excel and the Excel Solver before class, as it is used for within-class exercises. Students without the program and add-in installed may nevertheless participate within groups during the exercises.

**Prerequisites / notice**

The course does not take place this semester.

Introduction in basic skills for increasing the effectiveness and efficiency of students daily work.

1) know tools to "study in a paperless way"; have tried out these tools and made their own conscious choice of useful tools.
2) know tools to work efficiently and goal-oriented in teams.
3) can approach problems methodically correct; know important problem-solving techniques.
4) are able to handle scientific texts and sources correctly; know how to write scientific papers.
5) know how to avoid social problems in working teams and how to solve them when they exist.
6. Students are familiar with current developments and trends in supply chain practices.

**Literature**
- Braun Walter, Die (Psycho-) Logik des Entscheidens, Fallstricke, Strategien und Techniken im Umgang mit schwierigen Situationen, Huber, 2010
- Metzger Christoph, Wie lerne ich?:Ein Ü. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge. The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

**Prerequisites / notice**

None
Environmental Ethics

Abstract
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples from current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Content
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarization with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Lecture notes
Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

Literature
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O'Neill et al., Environmental Values, 2008

Generel introductions:
- Marcus Düwell et. al (Hrsg.), Handbuch Ethik, 2, Auflage, Stuttgart (Metzler Verlag), 2006
- Johann S. Ach et. al (Hrsg.), Grundkurs Ethik 1. Grundlagen, Paderborn (mentis) 2008

Prerequisites / notice
The procedure for accumulating CP will be explained at the start of term. We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

Cancer: Fundamentals, Origin and Therapy

Abstract

Objective
Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or chemical exposure and resulting in a tumor. They are able to list important cancer-inducing agents and explain the respective mechanism of action. They have knowledge of significant risk factors for cancer diseases. They are confronted with the basics of toxicology and they can explain the principle of the most common therapeutic strategies.

Content
The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process. Classes of chemical compounds that induce cancer are discussed as well as the reactive metabolites that may be built from. Covalent binding to DNA is discussed and different types of mutations resulting therof. A selection of proto-oncogenes and tumor suppressor genes is presented. Their function will be discussed as well as the changes which are found in these genes in tumor cells, starting from single nucleotide exchanges up to large deletions. The reason for genetic predisposition to cancer will be discussed as well as cancer relevant aspects of cell cycle regulation. The role of tumor microenvironments and phenomenons like angiogenesis and metastasis are presented as well as the mechanisms that protect the genome from mutagenic damage. Further subjects address old and new strategies of cancer treatment. Personalised cancer treatment.

Lecture notes
Handouts with reproductions of all presented transparencies will be distributed.

Literature

additional information is given during the lecture

The lecture requires an active participation of the students. All students will participate in individual or group work focussing on specific subject of the lecture. Students will have ample time for preparation during lecture time.

Ethics of Life Sciences and Biotechnology

Number of participants limited to 100

Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.
Objective

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Bachelor's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-0220-20L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>15 credits</td>
<td>32D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract

The Bachelor Thesis completes the Bachelor programme and consists of a scientific project carried out independently under the tutorship of a lecturer at D-HEST.

Objective

The Bachelor Thesis aims at fostering the student's ability to independent, structured and scientific working and at deepening their knowledge in a specific field.

Food Science Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>D</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### General Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>Z</td>
<td>3 credits</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
</tr>
<tr>
<td></td>
<td>Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Exercises) 351-0778-01.</td>
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<tr>
<td>Abstract</td>
<td>Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.</td>
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<tr>
<td>Objective</td>
<td>The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.</td>
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<tr>
<td>Content</td>
<td>The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.</td>
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<tr>
<td>Lecture notes</td>
<td>Through small group work, you will develop analyses of each of the cases. Each group will also submit a &quot;pitch&quot; with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Discovering Management (Exercises)</th>
<th>Z</th>
<th>1 credit</th>
<th>1U</th>
<th>B. Clarysse, L. P. T. Vandeweghe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Complementary exercises for the module Discovering Management.</td>
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<tr>
<td>Prerequisite</td>
<td>Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.</td>
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<tr>
<td>Abstract</td>
<td>This course is offered complementary to the basis course 351-0778-00L, &quot;Discovering Management&quot;. The course offers an additional exercise.</td>
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<tr>
<td>Objective</td>
<td>The general objective of Discovering Management (Exercises) is to complement the course &quot;Discovering Management&quot; with one larger additional exercise.</td>
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<tr>
<td>Content</td>
<td>Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.</td>
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<tr>
<td>Literature</td>
<td>Students who are enrolled for &quot;Discovering Management Exercises&quot; are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Introduction to Microeconomics</th>
<th>Z</th>
<th>3 credits</th>
<th>2G</th>
<th>M. Wörter, M. Beck</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GESS (Science in Perspective): This course is only for students enrolled in a Bachelor's degree programme.</td>
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<tr>
<td></td>
<td>Students enrolled in a Master's degree programme may attend &quot;Principles of Microeconomics&quot; (LE 363-0503-00L) instead.</td>
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<td></td>
<td>Note for D-MAVT students: If you have already</td>
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successfully completed “Principles of Microeconomics” (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Managerial Economics
Not for MSC students belonging to D-MTEC!

351-0511-00L
Z 4 credits
O. Krebs, P. Egger, M. Köthenbürger

Abstract
"Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

Objective
The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Literature

Prerequisites / notice
The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

Microeconomics
Not for students belonging to D-MTEC!

351-1034-00L
Z 3 credits
A. Fetz, M. Gysler

Abstract
Introduction to the economic decisions of households and firms, and their coordination through markets. Analysis of different market structures and of situations in which markets may lead to socially undesirable outcomes.

Objective
Understanding of basic microeconomic models. Ability to apply these models to real world economic situations.

Content
Economics as a science, division of labour and welfare (concept of comparative advantage), supply and demand (market equilibrium, elasticity), households (preferences, demand), firms (technology, cost analysis, profit maximisation, supply), perfect competition, monopoly and oligopoly, externalities, public goods, information, factor markets and income distribution

Lecture notes
via email

Literature

Prerequisites / notice
Course macroeconomics in the spring term

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Principles of Economics

Adaptability and Flexibility

The slides of the lectures are made available and updated continuously through the SMI website:

After successful completion of the course you will be able to:

Communication

Not for students belonging to D-MTEC!

The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through our cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.

Methods of the course include both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active lass participation is required.

This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through our cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

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The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.
Prerequisites / notice
Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

351-1158-AAL Principles of Economics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Students understand basic microeconomics and macroeconomics problems and theories. They are able to argue along economic principles and to judge policy measures.

Objective
Upon successful completion of the course, you will be able to:
- Describe the basic microeconomic and macroeconomic problems and theories.
- Make economic arguments to a given topic.
- Evaluate economic measures.

Content
Households, firms, supply and demand: How are household preferences and consumption behavior formed? How does a household react to price changes? How are goods prices formed? At what prices are firms willing to offer goods? How do we make economic decisions? Markets: What is “perfect competition” and how does a competitive market work? Are monopolies always a bad thing? How can governments influence the market? Market failure: What happens when prices give wrong signals? Labor market: How do supply and demand work in the labor market? What influences unemployment? National Accounts: How big is the Swiss economy? Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market? Money and inflation: What exactly is money? How does money creation work, and what happens when there is too much (or too little) money on the market?

Literature

363-0541-02L Systems Dynamics and Complexity (Additional Cases) Z
Only for Mechanical Engineering BSc.

Abstract
This module is an addition to the course Systems Dynamics and Complexity. It offers additional study cases to MAVT Bachelor students who enroll in the main course.

Objective
MAVT Bachelor students learn how to develop and analyze more sophisticated systems dynamics models from different areas, e.g. from biology (population dynamics, cooperation), management (inventory modeling, technology adoption and economics (supply and demand, investment and consumption), to name but a few. The goal is to apply analytical and numeric techniques to gain a deeper understanding of the dynamics of complex systems.

Content
1. Modelling path dependence and formation of standards
   - Why do clocks go clockwise? Why do people in most nations drive on the right? Why do nearly all computer keyboards have the QWERTY layout, even though it is more inefficient compared to DVORAK? It turns out that many real-world processes are path depended, i.e. small random events early in their history determine the ultimate end state, even when all end states are equally likely at the beginning. Students will learn how to model such processes, to understand the feedback mechanisms that lead to path dependence. As a case in point, we will study the ‘war’ between the Betamax and the VHS standards.

   2. Optimal migration as promoter of cooperation
      - Mechanisms to promote cooperative behaviour is a vibrant research topic in various fields - economics, evolutionary biology and management science to name but a few. Students will be introduced to one such mechanism - migration. They will develop and analyse a macroscopic model to study how the rate of migration affects the long-term cooperation rate in a population.

   3. Information transfer
      - Information flow in a social system (e.g. about the location of resources or appearance of a competitor) is an important component of group living. For example, it is well known that ants can achieve remarkable feats in finding an optimal route to a food patch through pheromone trails. The goal of this study case is to model information transfer in such systems by investigating the dynamics of trail formation in ants. The students will learn that the complexity in navigating to a food source may nevertheless be explained as a simple dynamical system with one control parameter only.

   4. Decisions in social societies
      - In many situations individuals have to decide between two or more options. Such decisions often have a profound impact on the system as a whole, especially regarding group cohesion. Group cohesion is preferred, as individuals can benefit from living in groups, yet it may not be the underlying reason behind individual choices. In this case, students will develop and extend a macroscopic model of an animal social system faced with a decision to choose a new home, and identify the conditions which promote group cohesion versus group splitting.

   5. Antigenic variation of HIV
      - One of the characteristic traits of HIV is that a host can be a carrier and a transmitter of the virus without experiencing symptoms for up to 10 years. This case is concerned with finding the mechanism of HIV disease progression. The students will develop a general population-based model for the interaction of an infectious agent with the host immune system. The model is applicable to a variety of infectious agents, ranging from acute lethal infections to chronic illness. Through analysing and simulating the model, the students will understand how the HIV virus interacts with the host and how the mutation rate of the virus is ultimately responsible for this long asymptomatic period.

   6. Compartamental models in epidemiology
      - Many diffusive processes in social systems, such as epidemics, can be understood as a result of the interaction between a few groups (compartments) of individuals. The most common example is to divide a population into those who are susceptible (S) to a disease, those who are infected (I), and those who have recovered (R) and are immune, and to model their interactions. These so called SIR models find wide application in studying non-biological diffusive processes, e.g. spread of technological innovations, fads, internet memes etc. In this study case, students will become familiar with the basic components of an SIR model and the conditions under which a disease can cause the outbreak of an epidemic. Students will extend the basic model to investigate more realistic scenarios relevant to e.g. different vaccination strategies.
### Management, Technology and Economics (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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</table>

### Key for Hours

<table>
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<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Core Courses

General Management and Human Resource Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0341-00L</td>
<td>Introduction to Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>Z. Zagorac-Uremovic, D. Baschung, J. O'Neill</td>
</tr>
</tbody>
</table>

**Abstract**
This course is an introduction to the critical management skills involved in planning, organizing, leading and controlling an organization. By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate routine operations in order to meet evolving customers’ and societal needs. The students will achieve these goals by being able to:
- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how a change, internally or externally initiated, impact such relationships

**Objective**
Selected readings from the book and additional learning materials will be available on the course Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15262

**Content**
Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on moodle. This preparation is required to participate in the lectures.

**Prerequisites / notice**
We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.

**Taught competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

**Method-specific Competencies**
- Innovation
- Co-learning
- Collaboration

**Social Competencies**
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Strategy, Markets and Technology

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0387-00L</td>
<td>Corporate Sustainability</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Hoffmann, J. Meuer, A. Nunez-Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

**Objective**
Students assess the limits and the potential of corporate sustainability for sustainable development - develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method - recognize and realize opportunities through team work for corporate sustainability in a business environment - present strategic recommendations in teams with different output formats (tv-style debate, consultancy pitch, technology model walk-through, campaign video)

**Content**
In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share his insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

**Lecture notes**
Presentation slides will be made available on moodle prior to lectures.

**Literature**
Literature recommendations will be distributed during the lecture

**Prerequisites / notice**
TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.
Introduction to Marketing

**Objective**
After taking the class, students will be able to:

1. Define what marketing is and describe its role at different stages of the value chain.
2. Apply psychological theories to analyze behavior (e.g., purchase behavior) and identify the needs of (prospective) customers in consumer and business markets.
3. Design elements of the marketing mix—e.g., develop new products and set prices—in a way that creates long-term value.
4. Create an effective and efficient marketing mix that attracts and engages customers, e.g., by running targeted promotions.
5. Use quantitative methods and customer data to manage relationships with customers.

**Content**
The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making.

The structure of the course will roughly follow the different steps of the value chain, i.e., the set of activities necessary for offering valuable products to customers. First, it will introduce students to psychological theories that help explain behavior, e.g., purchase behavior. It will also familiarize students with different methods from marketing research, which can be used to identify the needs of customers. Next, the course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing. A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

The course is designed to be "hands-on", with opportunities to apply skills on business cases involving real-world marketing data. It will feature guest lectures from industry experts. The class might be taught in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned reading material for self-study.

**Literature**

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Leadership and Responsibility</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Self-direction and Self-management</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>Negotiation</td>
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</tr>
</tbody>
</table>

Number of participants limited to 80.

**Abstract**
This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at improving and establishing position of firms within an industry.

**Objective**
The lecture "Strategic Management" is designed to teach relevant competences in strategic planning and -implementation, for both professional work-life and further scientific development. The course provides an overview of the basics of strategy and the most relevant concepts and methods in strategic management. The course is given as a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the case companies. In two sessions, the students will also be addressing real-time strategic issues of firms that are represented by executives.

**Content**

<table>
<thead>
<tr>
<th>Dates</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.09.2021</td>
<td>Guest Lecture (Dr. Berg) and Introduction</td>
</tr>
<tr>
<td>18.10.2021 Industry dynamics I: Industry analysis + Case Studies</td>
<td></td>
</tr>
<tr>
<td>25.10.2021 Industry dynamics II: Analysis of technology and innovation + Cases</td>
<td></td>
</tr>
<tr>
<td>15.11.2021 The resource-based theory of the firm + Cases</td>
<td></td>
</tr>
<tr>
<td>22.11.2021 The knowledge-based theory of the firm + Cases</td>
<td></td>
</tr>
<tr>
<td>29.11.2021 Guest Lecture (Andy Staubli, PwC) and course summary</td>
<td></td>
</tr>
</tbody>
</table>

Strategic Management offers a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the involved companies. This aims at offering students a profound theoretical understanding of important and current topics and also offer an opportunity to present these concepts in front of an audience.

This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at analyzing and establishing position of firms within an industry, securing firm performance. Thus, the course focuses on a number of important topics, such as the evolution of industry, industry structure, the analysis of a firm's resources- and knowledge, and innovation. In addition, student groups will hold presentations on the four main topics of this class, to further develop concepts and enhance understanding. The presentations will cover Industry Dynamics I, Industry Dynamics II, Resource Based View of the Firm, Knowledge Based View of the Firm. For all presentations, selected Harvard Business Cases will be used as a common ground for students to start from.

Students are also expected to read and understand the required readings (approx. 15 items) that cover the most important papers and articles from the past 30 years in management and strategy research. To underline the relevance of Strategic Management in firms, decision makers from companies in Switzerland will be holding guest lectures and give their take on strategy in practice and give insight on current topics in the field.
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can design information flows, manage master data, and use it to plan and control a factory.
9. Additional skills: Students acquire experience in teamwork.

For more information please see: http://www.smi.ethz.ch/education/practicing-strategy.html
Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM

Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. Factivery group assignment. Factivery allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.

The following textbook is supplementary:

The following textbook is recommended:

<table>
<thead>
<tr>
<th>363-0453-00L</th>
<th>Strategic Supply Chain Management</th>
<th>W+</th>
<th>3 credits</th>
<th>2G</th>
<th>S. Wagner</th>
</tr>
</thead>
</table>

**Abstract**
The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms competitive strategies and marketing priorities.

**Objective**
After completing this course:
1. Students can explain the importance of supply chain management for a firm’s strategy and success
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings
4. Students can describe and evaluate fundamental logistics and supply chain concepts
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
6. Students are familiar with current developments and trends in supply chain practices

**Content**
Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains ought to be aligned with and support the achievement of the firm’s corporate, business and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains. Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain’s role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

**Lecture notes**
The course material will be made available for download on Moodle:
https://moodle-app2.let.ethz.ch/course/view.php?id=17834

All organizational matters will be handled by the teaching assistant Christian Wagner (cwagner@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

**Literature**
The following textbook is recommended:

The following textbook is supplementary:
Students should install MS Excel and the Excel Solver before class, as it is used for within-class exercises. Students without the program and add-in installed may nevertheless participate within groups during the exercises.

### Quantitative and Qualitative Methods for Solving Complex Problems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0305-00L</td>
<td>Empirical Methods in Management</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Tillmanns</td>
</tr>
</tbody>
</table>

**Abstract**

In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created videos.

**Objective**

The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

**Content**

Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understanding of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature.

Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making.

We recommend the lecture also to students without basic statistical skills, who want to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.

The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to that, there will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.

**Literature**

Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.

**Prerequisites / notice**

The course includes out-of-class assignments and projects to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups. Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-1004-00L</td>
<td>Operations Research</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Bütikofer van Oordt</td>
</tr>
</tbody>
</table>

**Abstract**

This course provides an introduction to operations research methods in the fields of management science and economics. Requisite mathematical concepts are introduced with a practical, problem-solving perspective.

**Objective**

- Introduction to building and using quantitative models in a business / industrial environment
- Introduction to basic optimization techniques (Linear Programming and extensions, network flows, integer programming, dynamic and stochastic optimization)
- Understanding the integration of quantitative models into the managerial decision process

**Content**

The economic environment of today’s companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative models and methods of operations research and operations management offer decision support for complex problems.

Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analysed and optimized using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:
- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

A printed script will be made available.

**Literature**

Any standard textbook in Operations Research is a useful complement to the course.

**Prerequisites / notice**

Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0541-00L</td>
<td>Systems Dynamics and Complexity</td>
<td>W+</td>
<td>3</td>
<td>3G</td>
<td>F. Schweitzer</td>
</tr>
</tbody>
</table>

**Abstract**

Finding solutions: what is complexity, problem solving cycle.

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics.
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of the policymakers.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see "Prerequisites").

The set-up of the course will closely follow the book of M. Filippini. This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

### Micro and Macroeconomics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>J.-E. Sturm</td>
</tr>
</tbody>
</table>

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective Content**

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems. This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of the policymakers.

The set-up of the course will closely follow the book of N. Gregory Mankiw and Mark P. Taylor (2020), Economics, Cengage Learning, Fifth Edition. This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

### Taught competencies

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Literature

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

**Principles of Microeconomics**

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

**Abstract**

The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

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The learning objectives of the course are:

(1) Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

363-0537-00L Resource and Environmental Economics

Objective
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

### Literature

### Financial Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0711-00L</td>
<td>Accounting for Managers</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>H. Chen</td>
</tr>
</tbody>
</table>

**Abstract**
The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

**Objective**
By attending this course, students will be able to:
- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

**Content**
The first part of the course is devoted to financial accounting. It teaches the principles of double-entre accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

**Prerequisites / notice**
This course is a prerequisite for the course Financial Management.

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<tr>
<th>Number</th>
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<tr>
<td>363-0561-00L</td>
<td>Financial Market Risks</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>not available</td>
</tr>
</tbody>
</table>

**Abstract**
I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

**Objective**
The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

- Development of the concepts and tools to understand these risks and master them.
- Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)
- Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks
### Content

1. The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of the perpetual money machine.

2. Risks in financial markets
   - What is risk?
   - Measuring risks of financial assets
   - Introduction to three different concepts of probability
   - History of financial markets, diversification, market risks

3. Introduction to financial risks and its management.
   - Relationship between risk and return
   - Portfolio theory: the concept of diversification and optimal allocation
   - How to price assets: the Capital Asset Pricing Model
   - How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4. Financial markets: role and efficiency
   - What is an efficient market?
   - Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
   - Deviations from efficiency, puzzles and anomalies in the financial markets
   - Financial bubbles, crashes, systemic instabilities

5. An introduction to Options and derivatives
   - Calls, Puts and Shares and other derivatives
   - Financial alchemy with options (options are building blocks of any possible cash flow)
   - Determination of option value; concept of risk hedging

6. Valuation and using options
   - A first simple option valuation model
   - The Binomial method for valuing options
   - The Black-scholes model and formula
   - Practical examples and implementation
   - Realized prices deviate from these theories; volatility smile and real option trading
   - How to imperfectly hedge with real markets?

7. Real options
   - The value of follow-on investment opportunities
   - The timing option
   - The abandonment option
   - Flexible production
   - Conceptual aspects and extensions

8. Government bonds and their valuation
   - Relationship between bonds and interest rates
   - Real and nominal rates of interest
   - Term structure and Yields to maturity
   - Explaining the term structure
   - Different models of the term structure

9. Managing international risks
   - The foreign exchange market
   - Relations between exchange rates and interest rates, inflation, and other economic variables
   - Hedging currency risks
   - Currency speculation
   - Exchange risk and international investment decisions

### Lecture notes
Lecture slides will be available on the site of the lecture.

### Literature
- Corporate finance
- Brealey / Myers / Allen
- Eighth edition

Additional paper reading provided during the lectures.

### Prerequisites / notice
None

### Elective Courses

#### Economic Dynamics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>363-1137-00L</td>
<td>Applied Econometrics in Environmental and Energy Economics</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>D. Cerruti, S. Srinivasan</td>
</tr>
</tbody>
</table>

Number of participants limited to 40.

It is highly recommended to take 363-0570-00L Principles of Econometrics first.

**Abstract**
The course introduces to the most common empirical methods for the analysis of issues in environmental, energy, and resource economics. The course includes computer laboratory sessions, and covers the following broad topics: demand models, discrete choice models, empirical methods in policy evaluation, field- and quasi-experiments.

**Objective**
At the end of the course, the students will be able to: understand the most common empirical methodologies used in environmental, energy, and resource economics; understand the problems the methodologies learnt in class aim to address; appreciate the importance of causal inference in empirical economics; read and understand the research papers in the literature; apply the empirical methods learnt in class using the software R.
The course introduces students to empirical statistical methods that have wide application in environmental, energy, and resource economics and it is divided in four blocks. The first block is a quick review of the basic econometric methodology and concepts (OLS, standard errors, logit/probit models); the second block introduces demand models like the Almost Ideal Demand System, discrete choice models, and their evolutions; the third block explores causal inference in empirical economics and the main reduced-form econometric techniques used in policy evaluation, such as difference-in-differences, regression discontinuity and synthetic control; the fourth block introduces field experiments and instrumental variables, and their characteristics.

At the end of each block there will be a computer laboratory class in which the student will learn to apply the methodologies learnt in class using the statistical open-source software R. Throughout the course, students will have the chance to work on actual data used for analysis in economics papers.

The lectures will make use of current research papers in the literature to illustrate practical examples in which the methodologies learnt in class have been used. Students will be expected to read in advance the paper that will be explained during the lecture.

The evaluation policy has the aim to allow students to get practical experience on the econometric methodologies learnt in class. Thus, beyond a final open-book computer exercise exam (60% of the grade), the course includes short takehome computer exercises (40% of the grade).

As the course will be centered on econometric methods, it is recommended that students have taken 363-0570-00L Principles of Econometrics first, or have otherwise a solid knowledge of basic econometric methodologies as detailed in Part I of Wooldridge, Jeffrey M. (2018) Introductory Econometrics : A Modern Approach, Seventh ed. ISBN: 978-1-337-55886-0. Knowledge of statistical software R is helpful, but not required and will be taught in the computer laboratory sessions.

It is highly recommended to take 363-0570-00L Principles of Econometrics first.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Lecture Time</th>
<th>Prerequisites / Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-1136-00L</td>
<td>Dynamic Macroeconomics, Innovation and Growth</td>
<td>W 3</td>
<td>2V</td>
<td>S. Zelzner</td>
</tr>
<tr>
<td></td>
<td>Students who have successfully completed the course “Dynamic Macroeconomics” (364-0559-00L) or “Economics of Innovation and Growth” (363-0562-01L) can not register for this course.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Introducing dynamic models and workhorses in macroeconomics, understanding the role of innovation and institutions for economic development and discussing policies to foster innovation and economic growth, with a perspective on how digitization and artificial intelligence will affect our economies.</td>
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<td>Objective</td>
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<td>After the course, students will be familiar with dynamic general equilibrium theory and the basic workhorses in macroeconomics. Participants will be able to speak the Arrow-Debreu and recursive language and apply the frameworks to interesting issues, such as innovation and growth. Moreover, students will understand how the world has developed over the last centuries and the proximate and fundamental causes of innovation and economic growth. Students will understand and apply the basic models of economic growth and will be able to identify policies to foster innovation and growth and to reduce the large wealth differences in the world. Finally, they understand how digitization and artificial intelligence will drive the economies.</td>
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<tr>
<td></td>
<td>Literature</td>
<td></td>
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<tr>
<td></td>
<td>14. Current Literature on Digitization and Artificial Intelligence</td>
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</table>

Students who have successfully completed the course “Dynamic Macroeconomics” (364-0559-00L) or “Economics of Innovation and Growth” (363-0562-01L) can not register for this course.

<table>
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<tr>
<th>Course Code</th>
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</tr>
</thead>
<tbody>
<tr>
<td>363-1037-00L</td>
<td>Fiscal Competition and Multinational Firms</td>
<td>W 3</td>
<td>2V</td>
<td>M. Köthenbürger, M. Stimmelmayr</td>
</tr>
<tr>
<td></td>
<td>The course enables students to understand how multinational firms respond to differential tax regimes in a global economy and how countries strategically use the tax system to host multinationals. In particular, the course covers transfer pricing issues, internal financing decisions and agency problems and their relation to tax policy.</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1384 of 2345
After taking this course, students will be able to:
- understand how taxes influence decisions of multinational firms
- develop thinking about the strategic use of differential tax systems for multinational firms
- evaluate options for governments to respond to the tax planning behavior of multinational firms
- using theoretical models and empirical analysis to uncover regularities in how multinational firms respond to taxes

Multinational firms have grown in importance in recent decades. Given that their affiliates are located in different countries, they face various tax systems. This creates complexity with respect to the operation of a multinational firm, but also offers the option to benefit from differences across various tax provisions. Starting from this observation, the course looks at how multinational firms respond to the differences in tax provisions and how governments will respond to this behavior in their choice of tax systems. Different channels how multinational firms allocate taxable profits across countries will be analyzed: transfer pricing policies, internal financing decisions and investments. A particular emphasis will be put on how agency problems within multinational firms interact with tax avoidance behavior and how they are related to tax policy.

The course has two parts: The first part of the lecture contains a detailed treatment of the different channels multinational firms can use to strategically allocate profits to low-tax countries and how the tax avoidance decision might interfere with other decisions of the multinational firm. Building on this insight, we will discuss whether governments might strategically choose to adjust its tax provisions either to benefit from the multinational firm tax-saving behavior or to protect its tax base against the tax-planning behavior. In the second part of the course, we will discuss different papers that empirically analyze the validity of the different channels we have discussed in the first part. Students select one paper out of a list of papers (to be distributed in the course) and give a short presentation of the paper (max. 30 minutes). Afterwards, we will enter a discussion of the presented paper and clarify unaddressed issues.

The lectures will consist of both theoretical and practical components. In the theoretical part, we will discuss each estimation approach in detail. The lecture will present the assumptions, derivations, as well as the advantages and disadvantages of the estimation approach.

In the empirical part, we will look at simulation results using artificial data. Furthermore, we will investigate a particular research question using STATA.

The course will tentatively cover the following subjects:
- review of ordinary least squares (OLS) estimation
- instrumental variable estimation and two-stage least squares estimation
- seemingly unrelated regression models
- simultaneous equation models
- maximum likelihood estimation
- binary response models
- count data models
- censored and truncated regression models
- sample selection models
- treatment effect models
- static linear panel data models (random effects and fixed effects estimation)

For the theoretical portions of the lectures, we will prepare slides for in-class discussion. Slides will be distributed electronically before each lecture.

For the applied portion of the lectures, we will provide STATA do files, log files, and data sets.

Problem sets will also be made available after every lecture. These problem sets will not be collected or graded, but students can use them in order to prepare for the final exam. Solutions will be made available in the following lecture.

While there is no required textbook for the course, we draw from the following texts, which are also recommend for the preparation of the exam:

In the empirical part, we will discuss different papers that empirically analyze the validity of the different channels we have discussed in the first part. Students select one paper out of a list of papers (to be distributed in the course) and give a short presentation of the paper (max. 30 minutes). Afterwards, we will enter a discussion of the presented paper and clarify unaddressed issues.

The lecture provides an introduction to some of the central issues in labor economics, including the determinants of labor supply, firms’ demand for workers, minimum wages, unemployment, wage inequality, immigration, and labor market discrimination. It presents recent empirical research papers on these issues and discusses the empirical challenges related to their research designs.

After taking this course, students will be able to:
- analyze the behavior of actors in the labor market within the conceptual framework of economic theory.
- explain phenomena such as unemployment, wage inequality, labor market discrimination, and labor market imperfections.
- comment on policy-relevant issues such as minimum wages, a universal basic income, immigration, and unemployment insurance.
- comprehend and present the results of the relevant empirical studies on these issues.
- understand the challenges associated with a causal identification of research questions in the social sciences.
- comprehend the idea behind important statistical methods that modern empirical researchers apply to overcome these challenges.
In the course, students will get answers to relevant questions about modern labor markets: Who works, how much, and why? Do people work less if they have a universal (guaranteed) income or pay higher taxes? How does a firm determine its employment? Does a minimum wage reduce the employment of workers it intends to help? How does unemployment arise? What does unemployment insurance do, and what are its effects? What has driven the surge in wage inequality in developed countries in the last decades? What are the effects of immigration on resident wages and employment? Is there wage and hiring discrimination against women, men, and foreigners in the labor market, and why does it arise?

After presenting how modern labor economics conceptualizes these issues, the course discusses state-of-the-art empirical research papers that answer these questions. In the context of the topics, the course thus introduces students to basic statistical methods and data analysis techniques, including regression analysis and quasi-experimental methods. Students will also learn how empirical researchers use big data to get from correlations to causality. This introduction to modern applied economics does not require any prior background in economics or statistics.

The lecture targets students interested in the functioning of labor markets and the academic debate about specific labor market policies. A second target group is students that want to learn how modern empirical research in labor economics uses big data to analyze central issues in labor economics.

Students are expected to participate in the in-class discussions actively. They will also have the opportunity to read and present a key research paper on one of the topics discussed in class. The performance will be assessed based on a written exam at the end of the semester.

**363-1021-00L Monetary Policy**

**W** 3 credits 2V J.-E. Sturm, A. Rathke

**Abstract**
The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real world issues.

**Objective**
This lecture will introduce the fundamentals of economic analysis and explain the working and impact of monetary policy. The main aim of this course is to describe and analyze the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, and the differences between monetary policy rules and discretionary policy, as well as in institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.

**Content**
For the functioning of today’s economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls either the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today’s major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

**Lecture notes**
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17629) contains announcements, course information and lecture slides.

**Literature**

Basic knowledge in international economics and a good background in macroeconomics.

**Prerequisites / notice**

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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</table>

**363-1161-00L Time Series Econometrics and Macroeconomic Forecasting**

**W** 3 credits 2V S. Sarfaraz

**Abstract**
This course introduces the methods for analyzing and forecasting macroeconomic activity using multivariate time series analysis. We will study econometric models that central banks, government agencies and other research institutions use to analyze and forecasts macroeconomic variables.

**Objective**
How will the overall economy develop during the next quarters and years? What is the impact of the exchange rate on economic activity and inflation? How should we derive macroeconomic scenarios under alternative assumptions about the evolution of key variables like prices, exchange rates or the world economic activity? What are the effects of changes in monetary policy, fiscal policy or COVID-19 on economic activity? After completing this course, students will be able to tackle these and related questions using multivariate time series methods as applied by researchers and professional forecasters.
The course covers the following topics:

- Vector autoregressive (VAR) models
- Identification of macroeconomic shocks
- Conditional forecasting (macroeconomic scenario analysis)
- State space models
- Macroeconometrics and Big Data

During computer exercises, we utilize the time series models to study real world examples using R.

Prerequisites:

- Principles of Macroeconomics
- Principles of Econometrics

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-1047-00L</td>
<td>Urban Systems and Transportation</td>
<td>W</td>
<td>3</td>
<td>G. Loumeau</td>
</tr>
<tr>
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<td></td>
<td></td>
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<td>P. Mangold, T. Bolli, P. McDonald</td>
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</tbody>
</table>

### Objective

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

### Content

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the transport infrastructure mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today's economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

### Lecture notes

Course slides will be made available to students prior to each class.

Course slides will be made available to students.

<table>
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<th>Course Code</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>363-1107-00L</td>
<td>Youth Labor Market Outcomes, Institutions and Governance of Education and Training Systems</td>
<td>W</td>
<td>3</td>
<td>U. Renold, T. Bolli, P. McDonald</td>
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<td>P. Mangold, M. Eichhorn</td>
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### Abstract

Finding and retaining talent for companies is becoming increasingly important nowadays. While Switzerland has a comparatively efficient labor-market-oriented education system, other countries find it more challenging to develop the skills needed by the labor market. We will consider contributions of economics and other social sciences to understanding outcomes of education and training systems. Students can use case studies to identify and evaluate the different institutional features of labor-market-oriented education systems, and use those features to explain certain outcome effects on the youth labor market.

Students are able to deduce the consequences of countries' different initial institutional situations, to locate them culturally, and to point out problem-solving measures from the perspective of a company seeking improved skills preparation.

### Literature

- Principles of Econometrics
- Principles of Macroeconomics
- Principles of Economic Development
- Principles of Urban Economics
- Principles of Economic Geography
- Principles of Economic Policy

### Finance and Investment

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-1081-00L</td>
<td>Asset Liability Management and Treasury Risks</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Mangold, M. Eichhorn</td>
</tr>
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<td>Number of participants limited to 40.</td>
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### Abstract

Asset Liability Management (ALM) is key to the financial success of any corporation. The goal is to develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and related profits and losses, including identification and mitigation of undue risks taken. This course is geared towards preparing students to apply these concepts in practical settings.

### Objective

The main learning objectives of this course are:

- develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and their respective contribution to profits and losses
- measure and assess exposures to risk factors such as interest and FX rates, equity and commodity prices, as well as liquidity events
- trading and hedging to mitigate undue risks incurred
The course is organized around a series of case studies. We will first discuss and develop an understanding of the fundamentals on different aspects of the management and risk management of the balance sheet. Using real life case studies each concept will then be directly applied and tested. In-class discussions, presentations and one written assignment are used to facilitate active and interactive learning in a stimulating environment. During the case studies students will frequently work in small groups. Therefore, the number of participants is limited to 40.

The course focuses on the application of finance concepts to the financial management of corporations and is geared towards preparing students to apply these concepts in practical settings. Executives of all sectors are expected to have a sound understanding of the content covered. As such, the course is not exclusively targeted at students who are considering a career in the financial services sector. It also recommended for students who want to work in the finance, treasury or risk area of corporates. It is also suitable for students who want to work for a consultancy firm.

No single textbook covers the course, below we list some useful references. Further materials will be made available to students prior to the lectures.


Participants should have a basic understanding of financial management, gained, for example, from prior undergraduate economics, business, or accounting studies.

**Abstract**

"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

Upon successful conclusion of the course, students will:

1) know what corporate finance and corporate governance are about;
2) be able to price a wide array of corporate securities, assets, and projects, e.g., stocks, bonds, and options;
3) master three valuation approaches (discounted cash-flow valuation, relative valuation, and real-options valuation) and know about their applicability, their strengths, and their weaknesses;
4) know how to finance firms at different stages of their lifecycle;
5) be familiar with terms, acronyms, and concepts in the world of finance;
6) know how to relate real-world corporate events (past and current) to concepts learnt in class;
7) have increased their appeal as future manager, employee or entrepreneur by relevant knowledge in the field of finance in general and corporate finance in particular.

**Content**

"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

In the following, for each of the three parts of the course, key aspects, are listed.

**Part I: Corporate Finance and Corporate Governance**

- Corporations and their characteristics (e.g., centralized management, limited liability, free transferability of economic claims, legal personality)
- Corporate finance and its goals (e.g., shareholder-value approach vs. stakeholder-value approach)
- Corporate governance problems and possible solutions (e.g., over-investment, under-investment, self-dealing, monetary incentives, board of directors, the market of corporate control, leverage, product-market competition)

**Part II: Investment Decisions/Valuation**

- Discounting and compounding
- Present value tools (e.g., perpetuities, growing perpetuities, annuities, growing annuities)
- Bond pricing and interest rates (e.g., types of bonds, term structure of interest rates, yield-to-maturity, duration concepts, forward rates, "riding the yield curve")
- Risk and return (e.g., moments of stock returns, modern portfolio theory, capital market line, systematic risk vs. unsystematic risk)
- CAPM in practice (e.g., computation of the risk free interest rate, beta, and the market risk premium; security market line)
- DCF Analysis: Cost of capital and cash flow estimation
- Relative valuation (e.g., earnings multiples, book multiples, sales multiples, fundamental drivers of multiples)
- Real options (e.g., option to abandon, option to delay, option to expand)

**Part III: Financial Policy**

- Corporate financing (e.g., instruments, internal vs. external financing, equity financiing vs. debt financing, crowdfunding, M&M and beyond)
- Payout policy (e.g., dividends, par value reductions, share buybacks, M&M and beyond)
- Corporate finance and its goals (e.g., shareholder-value approach vs. stakeholder-value approach)
- Corporate governance problems and possible solutions (e.g., over-investment, under-investment, self-dealing, monetary incentives, board of directors, the market of corporate control, leverage, product-market competition)

**Literature**

Lectures notes

Slides in English (and any other relevant material) will be available for download on the following website: https://moodle-app2.let.ethz.ch/course/view.php?id=4479

**Human and Entrepreneurial Behaviour**

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-1082-00L</td>
<td>Enabling Entrepreneurship: From Science to Startup</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Sethi</td>
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</tbody>
</table>

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anisethi@ethz.ch
This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective

Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea

Content

The students would cover the following topics, as they build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It’s important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders’ agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Literature

Book

Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

Prerequisites / notice

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

Taught competencies

363-0311-00L

Psychological Aspects of Risk Management and Technology

<table>
<thead>
<tr>
<th>Number of participants limited to 65.</th>
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</table>

Abstract

Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are treated. Three components of risk management (risk identification/evaluation, risk mitigation, risk communication) and underlying psychological and organizational processes are discussed, using company case studies to promote in-depth understanding.

Objective

- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organisations
- Know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the covered material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).
The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Projects related to company case studies

There is no script, but slides will be made available before the lectures.

There are texts for each of the course topics made available before the lectures.

There is no script, but slides will be made available before the lectures.

The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

### 363-0790-00L Technology Entrepreneurship

**Abstract**
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

**Objective**
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.

A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

**Content**
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...)

2h lecture - schedule (±):
- 15': Introduction
- 60': (Guest) lecture
- 15': Discussion related to topic (in groups)
- 10': Plenary discussion
- 20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.


### 363-0301-00L Work Design and Organizational Change

**Abstract**
Good work design is crucial for individual and company effectiveness and a core element to be considered in organizational change. Meaning of work, organization-technology interaction, and uncertainty management are discussed with respect to work design and sustainable organizational change. As course project, students learn and apply a method for analyzing and designing work in business settings.

**Objective**
- Know effects of work design on competence, motivation, and well-being
- Understand links between design of individual jobs and work processes
- Know basic processes involved in systematic organizational change
- Understand the interaction between organization and technology and its impact on organizational change
- Understand relevance of work design for company performance and strategy
- Know and apply methods for analyzing and designing work

**Content**
The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterion
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

**Literature**
A list of required readings will be provided at the beginning of the course.

**Prerequisites / notice**
The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.
Abstract
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.

Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

Natural Resources

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<th>Hours</th>
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<td>Empirical Innovation Economics</td>
<td>W</td>
<td>3 credits</td>
<td>1G</td>
<td>M. Wörter</td>
</tr>
</tbody>
</table>

Abstract
The course focuses on important factors that drive the innovation performance of firms, like innovation capabilities, the use of digital technologies, environmental and innovation policy and it shows how innovation activities relate to firm performance and to the technological dynamic of industries. We also discuss the implications of the findings for effective economic policy-making.

Objective
The course provides students with the basic skills to understand and assess empirically the technological activities of firms and the technological dynamics of industries. In addition, the aim is to promote the understanding of the essential criteria for innovation policy-making.

Personal and social skills are also addressed during the course. In particular, there is the possibility to improve communication and presentation skills, the ability to develop arguments for the positions of political representatives, policy-makers, pressure groups, or NGOs in connection with innovation policy-making.

Content
The course consists of two parts. Part I provides an introduction into important topics in the field of the economics of innovation. Part II consists of important exercises based on various firm-level data sets, e.g., the KOF Innovation data, data about the digitization of firms, data about environmentally friendly innovations, or patent data. In part I, we will learn about ... a) market conditions that encourage firms to invest in R&D (Research and Development) and develop new products and processes. ... b) the role of competition and market structure for the R&D activities of companies. ... c) how digital and environmentally friendly technologies diffuse among firms. ... d) how the R&D activities of firms are affected by economic crises and how firms finance their R&D activities. ... e) how we can measure the returns to R&D activities. ... f) how environmental policies and innovation policies affect the technological activities of a firm. In part II we will use the KOF Innovation Survey data, patent data, data on digitization of firms, or other longitudinal data sources, to investigate empirically the technological activities of firms in relation to the topics introduced in part I.

Lecture notes
Will be provided in the course and in the e-learning environment: https://moodle-app2.let.ethz.ch/course/view.php?id=15120

Literature
Literature will be presented in the course. For an introduction into the economics of innovation see G.M. Peter Swann, The Economics of Innovation - an Introduction, Edward Elgar, 2009.

Prerequisites / notice
Course is directed to advanced Master-Students and PhD Students with an interest in empirical studies.

Taught competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

The Economics of Climate Change

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<th>Number</th>
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<th>Hours</th>
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<tr>
<td>363-1106-00L</td>
<td>The Economics of Climate Change</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Goussebaïle</td>
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</table>

Abstract
After an introduction to the issue of climate change, we will see the policy instruments that can be used to mitigate it. We will then discuss the optimal level of these policies. Finally, we will analyze the political constraints that limit their implementation.

Objective
Students will acquire a general understanding of the problem faced by the society with climate change, as well as the ways and the obstacles to deal with it. From a technical point of view, this course intends to teach participants the main tools used in economic sciences to discuss the problem of climate change, understand its key determinants, advise policy makers and understand the constraints of the latter.
The introductory part will explain why climate change represents a main issue for our societies. We will see the anthropogenic causes (i.e. greenhouse gas (GHG) emissions), the physical mechanism and the economic consequences of climate change. Then, we will introduce economic science modeling with the notion of externality to explain the excessive GHG emissions and characterize the societal challenge raised by climate change.

The second part of the course will present the different policy instruments for reducing GHG emissions (emission taxes, abatement subsidies, cap-and-trade system, standards). We will compare their performance and their distributional effects with regard to several aspects, with a special focus on the impact of uncertainty.

The third part of the course will focus on the level at which climate policies should be implemented, which depends on the cost of GHG emission abatement and the benefit of climate change mitigation. We will analyze the main drivers of the optimal emission abatement level, in particular discounting. We will also detail the economic models developed to evaluate the optimal abatement, namely Integrated Assessment Models.

The last part of the course will address the reasons why policy makers have only weakly implemented climate change policies up to now. We will discuss the difficulties of finding an international agreement for GHG emission reduction in a world with a large number of countries. We will also see why the time delay between GHG emissions and climate change may make society and policy makers reluctant to implement significant climate change policies.

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

Objective

The course has four core learning objectives. Students should:

- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as "deep learning") have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.
Today, we face the challenge of non-communicable diseases. Personal coaching approaches are neither scalable nor financially sustainable. The question arises therefore to which degree digital health interventions are appropriate to address this challenge. Students will design a just-in-time adaptive intervention.

The increasing prevalence of non-communicable diseases (NCDs) leads to the important question of how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, information systems research, computer science, and behavioral medicine, this last module of the CAS has the objective to help course participants to understand better the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions. After the module, participants will be able to understand better the...

1. design of a just-in-time adaptive intervention for the prevention of NCDs
2. technical implementation of a just-in-time adaptive intervention
3. evaluation of a just-in-time adaptive intervention.

What are the implications and rationale behind the recent developments in the field of digital health?

Digital Health is the use of information and communication technology for the prevention and treatment of diseases in the everyday life of individuals. It is thus linked to topics such as digital health interventions, digital biomarkers, digital coaches and healthcare chatbots, telemedicine, mobile and wearable computing, self-tracking, personalized medicine, connected health, smart homes, or smart cars.

In the 20th century, healthcare systems specialized in acute care. In the 21st century, we now face the challenge of dealing with the specific characteristics of non-communicable diseases. These are now responsible for around 70% of all deaths worldwide and 85% of all deaths in Europe and are associated with an estimated economic loss of $7 trillion between 2011 and 2025. Chronic and mental diseases are characterized in particular by the fact that they require an intervention paradigm that focuses on prevention and lifestyle change. Lifestyle (e.g., diet, physical activity, tobacco, or alcohol consumption) can reduce the risk of suffering from a chronic condition or, if already present, can reduce its burden. A corresponding change in lifestyle is, however, only implemented by a fraction of those affected, partly because of missing or inadequate interventions or health literacy, partly due to socio-cultural influences. Individual personal coaching of these individuals is neither scalable nor financially sustainable.

To this end, the question arises on how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, behavioral medicine, information systems research, and computer science, this CAS module has the objective to help participants interested in the multi-disciplinary field of digital health to understand better the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions (JITAIs).

After the module, participants will be able to understand better the...

1. design of a JITAIs for the prevention of NCDs
2. technical implementation of a JITAI
3. evaluation of a JITAI.

The lecture is structured in two parts and follows the concept of a blended treatment consisting of online-based self-learning sessions and complementary "coaching" sessions via Zoom. In the first part, participants will learn about the topics of the three learning modules in weekly online sessions. Complementary learning material (e.g., video clips), multiple-choice questions, and exercises are provided online via Moodle. In the second part, students work in teams and will use their knowledge from the first part to develop a smartphone-based and chatbot-delivered JITAI with MobileCoach (www.mobile-coach.eu), an open-source software platform for digital interventions and ecological momentary assessments. Each team will then present and discuss their resulting JITAI and evaluation results with their fellow students who will provide peer-reviews. Additional online coaching sessions are offered to support the teams with the design and evaluation of their JITAI, and with the preparation of their presentations.

The goal of the lecture is to understand the main challenges of corporate transformation and to demonstrate the application of a holistic approach to business transformation projects by introducing an integrated model dealing with three main design areas “strategy”, “processes” and “information systems” and applying this model to various case studies.

The globalization of the world leads to an increasingly faster pace in business transformation. Enterprises have to adapt faster and even faster to the environmental changes in a global economy to remain competitive and to make sure they stay in business. In today’s information age this does not only mean to adapt business strategy and business processes but also to adapt information systems to the new circumstances. The fast adaptation through large scale corporate transformation projects that change strategy, business processes and information systems is critical to ensure competitiveness for tomorrow. The introduction of new business processes and information systems typically takes years in very complex large scale projects. Many projects fail because of insufficient alignment between decision makers in business and IT. Unclear understanding of the overall project scope, undefined roles and responsibilities, unclear project processes, quality problems and resistance to change are some typical problems found in such projects. The lecture is subdivided into following modules:

- Corporate development introduction and motivation,
- Parallelization of corporate development and complexity reduction,
- Planning process and project portfolio management in corporate development,
- Management of large scale projects integration of strategy, processes and information systems,
- Quality management in large scale projects,
- Project management in large scale projects,
- Change management within projects.

The lecture is accompanied by four case studies that are used to exemplify the contents of the lecture by applying the concepts to real situations in corporate life.

### Systems Design and Risks

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<th>Number</th>
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<tr>
<td>363-1167-00L</td>
<td>Data Science for Social Challenges</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>R. Roller, L. Brandenberger</td>
</tr>
</tbody>
</table>

Many of today’s social challenges cannot be adequately grasped simply by observing human behavior. To make these challenges visible and address their causes, we can use advanced statistics to disentangle complex interdependencies between the driving factors. In this course, we build up methodological skills and places a strong focus on interpretation and reflection of results.

A successful participant of this course will be able to:

- interpret the results of data analysis with regard to the methodological choices and the operationalization of theoretical concepts
- assess potential flaws in research designs that can lead to flawed interpretations of results
- apply a wide variety of statistical models (e.g., regressions, difference-in-difference, network models) to different data sources
- and name the difference between statistical models and the advantages (or drawbacks) they hold for different data types
- name the limitations of observational data analysis, especially with regard to causality
- explain the importance of sensitivity and robustness checks for statistical analyses

In summary, a successful participant is able to assess quantitative social science research with regard to its research design, the model choice as well as the interpretation drawn from the estimates and make suggestions for improvements.
Content

Data Science for Social Challenges offers a practical approach to the quantitative analysis of human behavior and social interactions. While the course ‘Social Data Science’ focuses on data retrieval and processing, this course focuses on data analysis and interpretation of results.

The course is organized in three blocks of increasing data complexity. The first block tackles linear data analyses, where a dependent variable is modeled based on a set of independent and control variables. The second block tackles causal inference, where experimental settings are approximated with observational data to allow for causal interpretation of results. The third block tackles data sources where observations are not independent of each other and therefore defy most statistical models. Here, we examine how people interact with each other and how these interactions affect the people involved in turn.

The course covers various application of quantitative social sciences:
- measuring biases in societies
- analyzing behavior changes (due to internal or external events)
- studying deviant behavior and peer effects
- exploring coordination between people

The course makes the link to sociological theories and shows how they can be used to derive testable hypotheses. A strong focus is laid upon the operationalization of different concepts, such as finding an appropriate measure of deviant behavior or the level of animosity that exists between people at a given time. These measures are tested using appropriate statistical models. Here, the focus is put upon the interpretation (e.g., coefficient sizes and power) as well as the presentation of results (e.g., through marginal effects). Lastly, the course fosters critical thinking by discussing sensitivity and robustness tests. As such, the course offers insights into quantitative research design by following a hands-on approach to the study of societal challenges through social data science.

The course includes a lecture, student-led presentations and an accompanying exercise class. In the exercise class students get the opportunity to run through the whole data analysis process. Starting with data inspection, students operationalize theoretical concepts and test them on various statistical models. Strong focus is put on sensitivity checks, where the effect of changes to the model (i.e., adding another control variable) is assessed.

Literature

Interested students can peruse:


Prerequisites / notice

The statistical analyses in the course exercises are performed in R. Students should be interested in learning R skills to run sophisticated quantitative analyses.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Decision-making</td>
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<td></td>
<td>Problem-solving</td>
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</table>

Social Competencies

| Communication | assessed |
| Cooperation and Teamwork | assessed |
| Customer Orientation | not assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Negotiation | not assessed |

Personal Competencies

| Creative Thinking | assessed |
| Critical Thinking | assessed |

Resilience in the New Age of Risk

W 3 credits 2V H. Schernberg, C. Hölscher, J. Jörin, G. Sansavini

Abstract

With the global increase in interconnectivity, the potential for disruption is everywhere. Modern organisations who build resilience in all systems will respond intelligently to emergent disruptions. This course explores the concept of resilience and its application to socio-technical systems: The resilience of infrastructure systems and how individuals and social groups interact in and with them.

Objective

After taking this course, you will be able to:
- Discuss the concept of resilience and related frameworks and concepts, and explain their relevance in different contexts (organizations, infrastructure, social groups...).
- Use and discuss key resilience metrics and use them to analyze infrastructure systems.
- Discuss the role of organizational resilience and describe methods to improve it.
- Describe how resilience is applied in practice.
Our increasingly complex and connected systems face continuously emerging disruptions. Resilience constitutes a fundamental departure from the philosophy of risk-management. With resilience, stakeholders adopt risk mitigation strategies aligned to the theories of complex systems.

It is, however, difficult to learn about resilience, since it applies to an extremely large array of systems and contexts. Moreover, the topic of resilience is surprisingly absent from most university curricula. This course fills a gap and walks you through a mode of thinking that is bound to shape the way risks and disasters are dealt with in our increasingly connected society. Hence, tomorrow's risk managers will and shall also be "resilience managers".

This course breaks down the concept of complex systems and their resilience. It introduces some of the different flavors of resilience and provides tools for building it in various socially relevant areas (social resilience, engineered systems resilience, organizational resilience,...).

The course is divided in 4 parts.
- Part 1: Foundations of Resilience (2 hours)
- Part 2: Resilience Analysis: Infrastructure Systems (12 hours)
- Part 3: Organizational resilience and sensemaking (6 hours)
- Part 4: Resilience in Practice (4 hours)

Part 1 introduces the concept of resilience, and the framework in which it is applied. The distinction between resilience and risk management is highlighted, as well as how these approaches complement each other. The founding concepts of resilience are explained and illustrated: vulnerability, disruption, absorption, recovery, adaptation, etc.

Part 2 walks you through the analysis of the resilience of infrastructure systems. It introduces the useful metrics of resilience. It provides examples of building resilience into complex systems, by increasing the robustness and recoverability of systems, and reducing vulnerabilities. Finally, students will explore the optimization of infrastructure systems.

Part 3. Every system subject to potential disruptions is managed by a human organization. Sensemaking describes how humans frame the problem. It is a process whereby organizational actors attach meaning to external events to resolve the uncertainty surrounding them. Investing in mindfulness improves personal and organizational resilience and success. Finally, the management of organizational resilience is discussed.

Part 4 will provide examples of the use of resilience by practitioners, with guest speakers from the public and private sector.

This course is aimed at MSc and MAS students, from MTEC and other departments. Ideally, students have a quantitative background and some knowledge of risk management.

The Science and Practice of Resilience, Book by Benjamin D. Trump and Igor Linkov

363-1017-00L Risk and Insurance Economics

W 3 credits 2G H. Schernberg

Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
1) individual decision making under risk
2) models of insurance demand, risk sharing, insurance supply
3) information issues in insurance markets
4) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can -- or cannot -- play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.
**Main literature:**
- Handbook of the Economics of Risk and Uncertainty, Volume 1.

**Further readings:**

References will be given on a topic-by-topic basis during the course.

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### Taught competencies

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#### Technology and Innovation

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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0861-00L</td>
<td>Alliance Advantage - Exploring the Value Creation Potential of Collaborations</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. G. C. Marxt</td>
</tr>
</tbody>
</table>

**Abstract**
The development of new business models coping with the constantly augmenting complexity of technologies and systems as well as the ever increasing global competition force organizations to focus on close collaboration with key partners. These alliances are key value creation opportunities and constitute the core part of this lecture.

**Objective**
Learning outcomes professional competence
- The students learn and understand the management basics of inter-firm cooperation and organizational networks (business models, incl. risk, communication, etc.)
- realize the value creation potentials of alliances (added value)
- understand underlying theoretical models (Transaction cost theory, principal agent, game theory)
- Identify and understand specific forms of collaboration (Strat. All., JV, Networks, M&A, etc.)
- Apply tools hands on in real companies (in coll. with companies)

Learning outcomes methodological competence
- Writing academic papers
- Developing structured documentation of interviews
- Transferring theory directly into application
- Contributing to the learning journey

Learning outcomes social competence
- Work together with industrial partners
- Improving communication skills as basics for collaboration
- Developing and applying team work skills
- Coping with conflicts resolution in teams

**Content**
The constantly augmenting complexity of technologies and systems, the increased pressure caused by competition, the need for shortening time-to-market and the thereby implied growing risks force organizations to increasingly focus on core competencies. Collaboration with external partners is a key value creation opportunity for successful ventures. This type of cooperation also has implications on daily management activities. This lecture will provide a better understanding of special requirements needed for management of cooperation issues.

Content:
- Introduction to theory and management of inter-firm collaboration and networks.
- Description of the formation, management and evolution of collaborations and networks.
- Collaborations in marketing, development, manufacturing (e.g. NUMMI).
- Special forms of collaborations: mergers & acquisition (e.g. pre- and post-merger activities, joint venture, strategic alliances (e.g. Doz & Hamel, networks, virtual communities)

Learning journey:
In an introductory lecture we will give an overview of the theoretical framework and explain the concept of the lecture (first week of semester, Sept. 19, 2019). In weeks 2-5 you will work on a first assignment on six different aspects of the underlying framework: strategy and activities, structure and process, culture and people orientation, interaction and roles, risk and trust, knowledge and learning. This first assignment will give you the basics to participate in the second part (Nov. 7+8, 2019) of this seminar. There you will present the results of the first assignment and get additional theoretical input to perform the 2nd assignment. The second assignment will be to analyze real alliance projects in the partner companies. The final lesson will be used as a best practice exchange (Dec. 19, 2019).

**Lecture notes**
- Lecture script
- Current course material
- Harvard Case Studies
- Reader with current papers

**Literature**
A list with recommended publications will be distributed in the lecture.

**Classic Books:**
- HBR Collaborating Effectively ISBN 978-1-4221-6264 4
- HBR on Mergers and Acquisitions: ISBN 1-57851-555-6

**Prerequisites / notice**
The number of students participating in the lecture is limited to 30.
Objective

1. Understanding and applying common business tools and frameworks
2. Understanding current challenges of managers in technology intensive markets
3. Defining and analyzing comprehensive business problems using the example of a leading Swiss manufacturing company (Bühler AG)
4. Developing and evaluating different alternative case solutions
5. Making decisions on case solutions, justifying and defending them
6. Transferring case solutions into practice by formulating specific instructions for the management
7. Creation of novel, innovative ideas that help the company to gain a competitive edge
8. Cooperation in teams and coordination of team tasks
9. Adequate communication to and eye-level discussions with C-level managers

Content

The seminar “Cases in Technology Marketing” introduces students to key concepts and tools in technology marketing and familiarizes them subsequently with the challenges that (marketing) managers face in technology intensive markets by using real life cases. Students will have to work in groups and together solve past, current and future managerial problems in the form of cases. The team member composition will rotate for each case, enabling students to foster their teamwork abilities besides the application of theoretical concepts to the applied case questions. The students will have to present their case solutions to the lecturer and a top executive of a leading Swiss company (details see below). Also, they will be enabled to compare their solutions with what has actually been done or is yet to be done.

The three case studies presented in this course cover real managerial issues of the Swiss manufacturer Bühler AG (www.buhlergroup.com). A Bühler top executive will present the cases and discuss the students’ presentations and solutions. As such, the course allows for in-depth discussions of the real-life case solution with the C-level manager and hereby enables students to transfer their learnings from theoretical considerations to the applied field. The course will be rounded off with a day-visit to the Bühler facilities in Uzwil, Switzerland, where students will have the chance to further connect with management and discuss the acquired key concepts, tools, and case study insights on site.

Prerequisites / notice

In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 20.08.2021 to Theresa Schachner: tschachner@ethz.ch.

<table>
<thead>
<tr>
<th>363-0393-00L</th>
<th>Corporate Strategy</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>S. Ben-Menahem</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Due to didactic considerations, the number of participants for this course is limited to 45.</td>
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</tr>
<tr>
<td></td>
<td>Please register through myStudies to enroll for the course. Slots are assigned on a first-come first-serve basis (in the order of the registration date on myStudies). We will confirm your registration by email. If you have any inquiries about the course, please contact the course assistant.</td>
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</tbody>
</table>

Abstract

This course focuses on the challenges in managing multi-business corporations, and covers topics related to the vertical and horizontal scope of business activities.

Objective

The course is a combination of lectures about concepts/methods, guest lectures, case studies, and individual assignments.

Content

Large- and medium-sized corporations play a central role in the economic activity of most developed and developing countries. Many of these organizations perform multiple business activities in multiple markets. In the face of increasing international competition, globalization, technological development, deregulation, and the emergence of new markets and industries, operating such a portfolio of business activities poses important managerial challenges forcing corporations to continuously re-consider their vertical and horizontal scope and boundaries.

The course Corporate Strategy draws from a wide range of theories and methods to develop an understanding of the conceptual frameworks, debates, and developments concerning decisions associated with the management of multi-business corporations. We will cover the key questions driving a firm’s corporate strategy, including:

- In what markets to compete with which businesses?
- Which activities should be performed by the firm and which should be outsourced (i.e. “make” or “buy” decisions)?
- What are the most appropriate approaches to growth and divestiture?
- How do institutional forces impact corporate strategy?

Specifically, we will examine how organizations manage their portfolio of business activities and markets to achieve competitive advantage through vertical integration, cooperative strategies such as strategic alliances and joint ventures, corporate diversification, mergers and acquisitions, divestitures, and globalization/international strategies, and strategic renewal.

Prerequisites / notice

Having participated in the course Strategic Management by Prof. Georg von Krogh/Dr. Stephan Herting is an advantage but not a requirement.

Subject-specific Competencies

- Concepts and Theories

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Personal Competencies

- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

<table>
<thead>
<tr>
<th>363-1028-00L</th>
<th>Entrepreneurial Leadership</th>
<th>W</th>
<th>4 credits</th>
<th>3S</th>
<th>Z. Erden Özkol, S. Brusoni, H. Franke, O. von Dzengelevski, G. von Krogh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limited number of participants.</td>
<td></td>
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<tr>
<td></td>
<td>Students apply for this course via the official website no later than 21.08.2022 (<a href="https://www.mtec.ethz.ch/studies/special-programmes/els.html">https://www.mtec.ethz.ch/studies/special-programmes/els.html</a>). Once your application is confirmed, registration in myStudies is possible.</td>
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</tr>
</tbody>
</table>

Abstract

This seminar provides master and PhD students at MTEC with the challenging opportunity of a real case on strategy, innovation and leadership in close collaboration with the senior management of a leading Swiss healthcare company: F. Hoffmann-La Roche AG.

Objective

The general objective of the course is to enable MTEC students to develop leadership skills by dealing with real-world business problems, thinking critically about the concepts discussed in their study programs and learning how to apply these concepts to provide practical implications. It provides students with coaching and mentoring from senior leaders in the company and professors from D-MTEC to bridge the gap between theory and practice.
Industry and Competitive Analysis (ICA) is an essential part of any strategic management process. It contains a very practical set of methods to quickly gain a good grasp of an industry. The purpose of ICA is to understand factors that impact the financial performance of an industry and of firms within that industry, thereby enabling firms to develop effective competitive strategies.

What you can expect:

You will work in teams on specific high priority assignments that flow from the company. Delving into the assignments you will both contribute to solving strategic issues and have an impact on their implementation at the company.

To gain insight into the company and its culture you will receive briefings from senior management, conduct interviews with experts and run workshops with your case managers. In the final presentations you will pitch your findings to key stakeholders and top management representatives and receive valuable feedback.

Furthermore you will be coached and supported by MTEC professors on the topics of project scoping, problem definition and solving, process improvement, strategy and board presentation.

The course is directed and organised by PD Dr. Zeynep Erden and Dr. Isabel Spicker as part of the MTEC Leadership Development Programme.

What we expect from you:

You are an ambitious ETH student or doctoral candidate who is looking for a rewarding learning opportunity and is eager to go the extra mile. You will work on a real case study of strategy, technology and innovation in close collaboration with the senior management of an outstanding Swiss company. The recommendations that you formulate in collaboration with members of your team as well as with internal and external experts will be discussed at the Partner and Director levels. This demands a deep understanding of the company's leadership culture.

In this endeavour you are coached and supported by
- Stefano Brusoni, Chair of Technology and Innovation Management
- Georg von Krogh, Chair of Strategic Management and Innovation
- Torbjörn Netland, Chair of Production and Operations Management
- Zeynep Erden, Lecturer, D-MTEC

Literature and readings will be announced in the coaching sessions.

Due to didactic reasons originating from the group-work based approach, the number of participants is limited to 30. First come first served by order of enrollment in myStudies.

Experience in statistical analysis with tools such as SPSS or equivalents is an advantage.

Industry and Competitive Analysis (ICA) is an essential part of any strategic management process. It contains a very practical set of methods to quickly gain a good grasp of an industry. The purpose of ICA is to understand factors that impact the financial performance of an industry and of firms within that industry, thereby enabling firms to develop effective competitive strategies.

Content

Industry and Competitive Analysis (ICA) is an essential part of any strategic management process in firms and other organizations. It contains a very practical set of methods to quickly gain a good grasp of an industry. Be it pharmaceuticals, information and communication technologies, or the beer industry. The purpose of ICA is to understand factors that influence the performance of an industry and of firms within that industry. Developing such understanding supports firms in developing effective competitive strategies.

As the world witnesses tremendous development in digital technologies, many industries are in the midst of transitioning from analogue to digital business models. Digitalization is radically changing what firms produce and the way they organize their business activities. To adapt to these changes, practitioners and scholars alike need a more advanced set of analytical tools to understand the constantly-changing industries. That is why we have developed our course as ICA 2.0, which provides state-of-the-art tools to gain an updated picture of various industries before and after their digital transformation. In this course, we will study theoretical frameworks, examine evidence from empirical research, and benefit from experience shared by our guest speakers.

The course is organized as a combination of lectures, case studies, and tutored group work involving the selection and analysis of industries, analysis and development of strategies for selected firms, and presentation of results.

Grades:
- 50% paper/industry report (group)
- 50% final presentation (group)

ECTS: 4

Due to didactic reasons originating from the group-work based approach, the number of participants is limited to 30. First come first served by order of enrollment in myStudies.

Participants receive a certificate.
This course is built upon a management classic (Competitive Strategy: Techniques for Analyzing Industries and Competitors by Porter, 2004). We also draw from more recent research findings and practitioner-oriented strategy research. Readings associated with each lecture should be done before the lecture day.

To access the journal articles listed below, you have to be within the ETH domain (either directly connected to the ETH network within ETH or using VPN). PDF versions of the Harvard Business Review articles are only available via the class Moodle.

**Competitive strategy**
- Chapter 2 of Porter (2004)
- Case study: Southwest Airlines

**Industry Dynamics**
- Chapter 3 of Porter (2004)
- Case study: Southwest Airlines

**Strategic groups & firm membership**
- Porter in the Digital Age

**Opportunities & Resources**

**Competitive Analysis**

**Prerequisites / notice**
Due to high intensity of the tutoring format, the number of students is limited to 30. Students will be accepted according to the order of enrollment in myStudies. Exchange students can register by sending an e-mail to sherath@ethz.ch if facing problems with registration to myStudies. Registration will be handled individually, case by case. E-mails that are sent before the starting date of registration to myStudies will not be accepted.

An electronic confirmation of the registration will be sent out shortly before the start of the semester, which contains an access link to the Moodle page of the course (readings, resources for group works, group assignment).

Note that class participation is important. Students should make sure that they can attend each weekly lecture prior to registration.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories assessed</td>
<td>Analytical Competencies assessed</td>
<td>Communication assessed</td>
<td>Critical Thinking assessed</td>
</tr>
<tr>
<td>Decision-making assessed</td>
<td>Problem-solving assessed</td>
<td>Cooperation and Teamwork assessed</td>
<td>Self-direction and Self-management assessed</td>
</tr>
<tr>
<td>Project Management assessed</td>
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</table>

This course requires preparation time and completion of an assignment before the first course day. Please check the Moodle course page for more information.

**Abstract**
Students learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop their own research projects.

**Objective**
You will learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop your own research project. The successful completion of the course will help you to:
- Think critically and make compelling arguments about the strengths and weaknesses of published management research
- Find and review appropriate literature and previous research for your thesis
- Develop and frame interesting and relevant research questions and problem statements
- Design your research and choose an appropriate methodology for analysis (specific research methods and techniques are not discussed in this course)
- Structure your manuscript
- Plan and manage your thesis project

**Management Research**
Participation in both sessions and completion of all assignments is required to receive the credit.

Autumn Semester 2022
Content

This course combines lectures, group discussions and individual assignments.
Day 1: Course introduction, group analysis exercises and discussions, lectures on main topics.
Between course days 1 and 2: Individual and group work on assignments.
Day 2: Assignment review and discussion, lectures on main topics, conclusion session.

Target audience:
The course is designed with two groups of students in mind: first, students who write their master thesis at the SMI chair and second, students who write their master thesis in the field of management at other MTEC chairs.

For both groups, the focal topics of this course will arise frequently during the journey of writing their thesis, and the majority of topics are relevant for all students. However, we will provide some specific content (grading guidelines, thesis format) which might not be applicable for students tutored at other MTEC chairs.

Course topics:
1. Thesis topic and thesis proposal:
   - Choice of thesis topic, identification of research gap, formulation of research questions, writing of thesis proposal
2. Literature review:
   - Search and evaluation of academic literature, use of reference tools, writing of theoretical background chapter of thesis
3. Empirical research design:
   - Types of empirical research designs, choice of methodology, overview of data collection and analysis methods
4. Research output and report:
   - Writing of introduction, results and conclusion, thesis format and structure
5. Thesis assessment:
   - SMI grading criteria, MTEC guidelines

References:

Prerequisites / notice
This course is for all students who write their master thesis at the Department of Management, Technology, and Economics.

The course is required for all M.Sc. students and MAS students who write their master thesis at the Chair of Strategic Management and Innovation.

The course is graded based on the assignments, peer feedback, and participation in group discussions.
The first assignment is due before the first course day. Please check the assignments on the Moodle coursepage. If you sign up for the course on short notice before the first course day, please advise the lecturer of your registration by email.

Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0881-00L</td>
<td>Semester Project Small</td>
<td>W</td>
<td>3</td>
<td>6A</td>
<td>Professors</td>
</tr>
</tbody>
</table>
| Abstract   | The semester project (90 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.
| Objective  | The semester project (90 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution. |
| 363-0883-00L | Semester Project Large         | W    | 6    | 13A   | Professors  |
| Abstract   | The semester project (180 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.
| Objective  | The semester project (180 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution. |
| 363-1042-00L | Strategic Career Development  | Z    | 0    | 1V    | P. Cettier  |
| Abstract   | The offer Strategic Career Development has the goal to support students in the development and alignment of their personal & professional goals. Orientation. Goal setting, action plan development, motivation letter, CV, interview training
We will include high level external guest speakers
| Objective  | We will discuss and develop answers to the following questions:
|            | What do I want to achieve in my life?
|            | Why is it so important to define goals?
|            | What decision criteria can I use as a guide?
|            | How do potential career paths look like? What are the possibilities?
|            | How does the life cycle of a career look like? What are the alternatives?
|            | How do I increase my chances of success/reaching my goals?
|            | How did others do it? What kind of advice can experienced captains of industry give?
|            | Why is a periodic check of my goals and my progress necessary? |
INTRODUCTION
Awareness building / Overview on the career life cycle / Examples from praxis / Exchange of experiences / Approach for goal setting / Introduction to the success secrets of a career

ORIENTATION AND GOAL SETTING
Class discussion of the success secrets of a career/ Orientation on career options / Discussion of possible decision criteria / Initial formulation of concrete goals

External guest speaker: Inspiring Start-up Entrepreneur

CAREER DEVELOPMENT PLANS
Exchange w/ representatives of industries / Personal Values & Norms vs Corporate Identity / Work-Life Balance Gender / Diversity / Summary of discussions / Best practice / Modification/Sharpening of goals

External guest speaker: Representatives from Hilti AG Switzerland

DETAILED AND GOAL SETTING
Development of detailed individual career plans / Next steps / action plan / Tips & Tricks for careers in organizations and entrepreneurship

REVIEW & APPLICATION COUNSELING
Review/check of goals and career plans / Motivation letter / CV / Preparation for interviews

INTERVIEW TRAINING
Lecture notes

In today`s world of everything is possible it becomes an every increasing challenge to find orientation, to define a goal for which it is worth to work for with focus and energy. But this is exactly what is so important in today`s work environment. Only with a definite goal one can decide if the taken path is right, one can develop enough motivation to go beyond the comfort zone. With a definite goal, one increases the chances of success of one`s education and career. The earlier one has defined what he/she wants to achieve, the bigger the effect.

Prerequisites / notice

Motivation. Strategic long-term view.

Supplementary Courses
The students have to deepen their knowledge in the area(s) of engineering/natural sciences in consultation with the responsible professor (tutor). Core courses and electives of D-MTEC can not be used as supplementary courses.

Course Catalogue of ETH Zurich

Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0879-00L</td>
<td>Practical Training</td>
<td>O</td>
<td>6 credits</td>
<td>external organisers</td>
<td></td>
</tr>
</tbody>
</table>

Abstract
The practical experience gained by the student completes the studies at the Swiss Federal Institute of Technology and prepares her/him for future activities in industry.

Objective
The practical experience gained by the student completes the studies at the Swiss Federal Institute of Technology and prepares her/him for future activities in industry.

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0600-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>57D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme;
c. internship fulfilled;
d. academic writing course has been completed.

Abstract
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is supervised by the tutor and normally deals with a subject contained in the major fields. The research will be performed normally within a private company or at the ETH Zurich.

Objective
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is supervised by the tutor and normally deals with a subject contained in the major fields. The research will be performed normally within a private company or at the ETH Zurich.

Academic Writing Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-1063-00L</td>
<td>Academic Writing Course</td>
<td>O</td>
<td>0 credits</td>
<td>1G</td>
<td>R. Mihalka</td>
</tr>
</tbody>
</table>

Compulsory for all MTEC MSc students. Attendance of the initial lecture is compulsory. Students who are unavailable at the time of the initial lecture need to take the course in another semester.

Abstract
This course for MTEC master's students will focus on developing and refining students' English writing skills and their understanding of the requirements and conventions of academic writing.

Objective
The course develops a range of practical and transferrable writing skills. Its first aim is to improve the academic writing skills necessary for the successful completion of an MSc thesis. The course provides theoretical input, practical writing exercises, and detailed individual feedback. It is organized into an initial group lecture and four subsequent workshops in smaller tutorial groups.

The group lecture raises awareness about academic conduct, especially with regard to plagiarism. Afterwards, students take placement tests so that the areas where they need improvement can be identified. The following workshops concentrate on these highlighted areas, and feedback on placement tests is integrated into the input and practice during these sessions.

Students can use the skills developed on the course to improve the overall quality of their MSc theses and to produce their thesis more rapidly and efficiently. These skills can also be used beyond the MSc, whether students go on to complete a PhD or to produce reports and other documents in industry.
Content

Group lecture:
an introduction to writing an MSc thesis in D-MTEC
selecting topic and supervisor
academic expectations
avoiding plagiarism

Workshop 1:
the writing process
reading, note taking and planning
overview of the thesis structure
building academic vocabulary

Workshop 2:
writing methods sections
embedding figures and tables
structuring sentences and paragraphs
noun phrases and articles

Workshop 3:
introductions, results and discussion sections
writing critically
relative clauses

Workshop 4:
abstracts and conclusions
editing your own text
punctuation, spelling, and grammar

Lecture notes
 Notes will be available after registration.

Management, Technology and Economics Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Advanced Fundamentals of Mechatronics Engineering

Advanced Fundamentals

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>173-0007-00L</td>
<td>Dynamics</td>
<td>O</td>
<td>5</td>
<td>11G</td>
<td>E. Chatzi, V. Nertimanis, P. Tiso</td>
</tr>
</tbody>
</table>

Abstract
The course offers an introduction to dynamics of engineering systems. The first part focuses on Newtonian dynamics and energy principle to systems of particles and rigid bodies. The second part focuses on the free and forced response of single- and multi-degrees-of-freedom linear systems. Hands-on exercises, computer-based labs and experimental demos will support the theoretical lectures.

Objective
After successful completion of this course the students will be able to:
1. Set up the kinematic description of a system of particles and rigid bodies subject to constraints.
2. Formulate the governing equations of motion of a system of particles or of rigid bodies using balance law.
3. Alternative from the above, the student will be able to derive the equations of motion using Lagrange’s equations, d’Alembert’s principle, and Hamilton’s principle.
4. Find the equilibrium configurations of a given system, and perform linearization.
5. Compute the dynamic response of discrete systems to harmonic, periodic, pulse, and impulse excitation using time-history and response-spectrum methods.

Content
Day-by-day course content:
- Week 1
  - Day 1 – Recap on Newtonian Dynamics for single particle
  - Day 2 – Kinetics of systems of particles
  - Day 3 – Kinetics of Rigid bodies
  - Day 4 – Analytical mechanics
- Week 2
  - Day 6 – Mechanical Vibrations
  - Day 7 – Elements of Structural Vibration - SDOF
  - Day 8 – Elements of Vibration Theory - MDOF
  - Day 9 – State Space Representations
  - Day 10 – Transformations

Literature
The material will be organized in lecture slides.

A specific list of books will be offered as useful/supplemental reading.

173-0008-00L Introduction to Digital Electronic Circuits

Abstract
This lecture introduces basic digital circuit components. The first part focuses on logic gates, and their realization with CMOS transistors. The physics and the operation principle of transistors will be analyzed in details. Then, the Boolean algebra, codes, as well as the synthesis and analysis of simple circuits will be discussed. The second part is dedicated to latches and flip-flops.

Objective
Students should master the basic concepts of digital electronics, recognize its fundamental logic blocks and understand the basic physical operation mechanism CMOS transistors. Additionally they will be able to assemble them to create their own digital circuits, gather experience in the field of digital electronics, and become familiar with the design of simple and more advanced digital circuits, for example finite-state machines and memory cells.

Prerequisites / notice
Prerequisites: This course has no specific prerequisite, except basic knowledge of electrical engineering concepts, in particular Ohm’s and Kirchhoff’s laws. They will be repeated during the first lecture to ensure that everybody is on the same page.

173-0009-00L Statics and Solid Mechanics

Abstract
The course introduces general methods for the analysis of stress and deformation states in mechanical parts, as needed to optimize their design and to ensure their mechanical integrity. Starting from the derivation of the basic problem, the concepts are extended to consider anisotropic materials, plasticity, viscoelasticity and viscoplasticity. Examples of engineering applications are discussed.

Objective
The students will be able to analyse mechanical problems, to formulate and apply design criteria involving strength, local plastification, plastic collaps, fatigue and creep. They will understand how mechanical theories are derived from basic principles as well as the role of phenomenological models. They will learn different representations of the deformation behaviour of engineering materials and the implications for the assessment of products’ function and mechanical damage. They will know how to use advanced mathematical tools to solve engineering problems.

Taught competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
- Social Competencies
  - Communication
  - Cooperation and Teamwork
- Personal Competencies
  - Creative Thinking
  - Critical Thinking

173-0010-00L Computational Methods

Abstract
This course introduces students to numerical methods commonly used in engineering with a focus on finite element (FE) analysis. Starting with finite differences and ending with static and dynamic FE problems, students will learn the fundamental concepts of finite elements as well as their implementation and application.

Objective
To understand the concepts and application of numerical techniques for the solution of initial boundary value problems in solid and structural mechanics, particularly including the finite element (FE) method for static and dynamic problems. To understand the structure of FE codes and the right use of FE technology.

Content
Numerical methods and techniques for solving initial boundary value problems in engineering solid mechanics (heat conduction, static and dynamic mechanics problems of solids and structures). Finite difference methods, indirect and direct techniques, variational methods, main focus on the finite element (FE) method, FE analysis in small strains for applications in structural mechanics and solid mechanics.

Lecture notes
Typed lecture notes will be made available online.
<table>
<thead>
<tr>
<th>MAS in Advanced Fundamentals of Mechatronics Engineering - Key for Type</th>
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<tbody>
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<tr>
<td>R</td>
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</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
In this module, basic paradigms and techniques in working with data will be discussed, especially towards data security, managing data and the following programming concepts are introduced during this module:

1. Variables, data types
2. Condition check, loops, logics
3. Arrays
4. Functions
5. Matrices
6. Data management (SQL)

In the practical part of the course, students work on small programming projects with a context from natural sciences. Electronic tutorials are available as preparation.

Prerequisites / notice
No prior knowledge is required for this course. It is based on application-oriented learning. The students spend most of their time working through programming projects and discussing their results with teaching assistants. To learn the programming basics there are electronic tutorials available.

265-0100-00L Foundations of Programming
ECTS 3 credits
Type O
Hours 2A
Lecturers L. E. Fässler

Abstract
The initial module offers a practical introduction to some basic concepts and techniques for information processing as well as practical applications of them. The programming language are Python and SQL.

Objective
Students learn...
- how to encode a problem into a program, test the program, and correct errors.
- to understand and improve existing code.
- to implement mathematical models as a simulation.

265-0101-00L Data Science
ECTS 3 credits
Type O
Hours 3V
Lecturers B. Gärter

Abstract
In this module, basic paradigms and techniques in working with data will be discussed, especially towards data security, managing data and learning from data.

Objective
Participants learn about some important computer science concepts necessary for data science. They understand some of these concepts in detail and see the mathematics behind them.

Content
Participants get an introduction to key computer science concepts underlying current and upcoming technology. The module in particular covers crytopgraphy and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). Each topic will be discussed in two different ways: (i) a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments; (ii) a context part that addresses the challenges and limitations encountered in practical applications.

265-0102-00L Data Modeling and Computer Vision
ECTS 3 credits
Type O
Hours 2V
Lecturers E. Konukoglu

Abstract
This module offers practical knowledge in visual information processing and human computer interactions.

Objective
Participants understand basic concepts of visual recognition and human-computer interaction systems.

Content
The first part of the module will cover basic theoretical knowledge on visual recognition systems of the last two decades, mostly focusing on the most recent advancements in deep learning and convolutional neural networks. The theoretical knowledge will be supported with practical sessions that will allow participants to gain hands-on experience with most commonly used tools and deepen their understanding of the key concepts. The second part provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.

265-0103-00L Applied Information Technology
ECTS 3 credits
Type O
Hours 3V
Lecturers M. Brandis

Abstract
This integration module for CAS “Applied Information Technology” links technical understanding of technology with business strategy based on a set of case studies from practice.

Objective
Participants will learn how technology affects businesses and practical issues when using new technologies in incumbent organizations.

Content
Participants will explore how new information technologies change different aspects of a business, and learn how to evaluate specific risks, costs, and benefits of such technologies. The module will shed light on success factors and common pitfalls when implementing new technologies and respective business changes, and it will specifically address the communication between technical experts and business management. The studied cases are currently planned to focus on artificial intelligence, IoT including edge and cloud computing, blockchain and distributed ledger technologies, and cybersecurity and data protection regulations (subject to change).

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1406 of 2345
The Innovation Ecosystem

In most organizations, the R&D organization is the one that delivers the innovation to be brought to the market. In this module, we investigate the inner working of the R&D organization by exploring roles and processes. Since R&D almost always starts with significant uncertainties and unsolved technical problems, governing R&D has to account for these unknowns. As R&D processes take time in which the market environment may change in ways other than predicted at the beginning of a project, external influences have to be continuously monitored as well to enable market success.

The Innovation Opportunity Analysis course is designed as a practical introduction to evaluating technology-based innovation opportunities and applying a decision framework to select the project in question. The goal of this module is to complete the R&D and innovation framework and make the key points available in the context of the organizations’ environment.

Experimental Project

The topics include:
- Conceptualization of an idea and planning the realization
- Mechanical design of housing and mechanical components using CAD software
- Manufacturing of mechanical components using a 3D printer
- Electrical design of circuits and PCBs using ECAD software
- Assembly and soldering of PCBs
- Programming embedded software to run on a microcontroller on the designed PCB
- Testing of the desired functionality and measurement of the electrical workings
- Report of the process, the finished prototype and analysis of generated data

The project encompasses the conceptualization, realization and testing of a complete, functional technical system. This covers the initial idea, mechanical concept, electrical design, programming of software, measuring function and analysis of data. The goal is to give the participants a wide range of experiences in hardware and software, touching every aspect of R&D prototype development. The development will start from the ground up, using pre-fabricated components as little as possible. The participants are encouraged to come up with their own project ideas and pursue them with continual support from APS. Example projects will be available for inspiration and as templates and can be adopted instead of an own idea with as little or as many modifications as desired. Large parts of the project can be completed independently, using freely available software running on the participants’ computer and corresponding education resources. Some meetings will be scheduled for teaching and discussion and several hands-on sessions in the APS lab will be necessary for manufacturing and testing of the prototypes.

Master’s Thesis

The topic of the independent Master’s thesis should focus on a technical problem and can be related to a specific business case. The problem and technology evaluated are freely selectable, but must be approved in advance by the thesis supervisor.

- Report of the process, the finished prototype and analysis of generated data
- Testing of the desired functionality and measurement of the electrical workings
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Objective

The thesis should be integrative of the science and technology material and skills learned during the programme, particularly:

- Understand and apply the foundations of the area of science and technology relevant to the topic,
- Understand and describe the technical barriers to applying a technology successfully, and
- Respective documentation using precise and targeted technical language.

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MAS in Applied Technology - Key for Type

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Key for Hours

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ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
MAS in Architecture and Digital Fabrication

The MAS Digital Fabrication is a 1 year full-time programme and is structured as a series of teaching modules with an independent master thesis. Lessons within the modules are given in the form of lectures, practical workshops, and projects as the main modus for developing skills. Learning will be supported through one on one mentoring in studio, group critiques, symposia, and excursions.

Module

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<thead>
<tr>
<th>Number</th>
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<tr>
<td>069-0001-00L</td>
<td>Digital Foundations</td>
<td>O</td>
<td>20 credits</td>
<td>2G</td>
<td>B. Dillenburger, F. Gramazio, M. Kohler</td>
</tr>
</tbody>
</table>

Abstract

Digital Foundations introduces students to information technology in architecture, to computational design and how robotic fabrication processes as well as 3D printing technologies are used to translate computational design models into physical objects and building components.

Objective

Students learn basic programming paradigms such as control structures and object oriented programming, the foundations of computational geometry and explore generative form-finding. Using Python as a main programming language within the frameworks of Processing, Rhino and Grasshopper, students learn to translate design thinking into computational algorithms. Furthermore, students learn about data preparation and toolpath creation for 3D printing (predominantly binder jet-printing and fused-deposition-modelling), and familiarise themselves with various mechatronic setups, materials and control-strategies of additive manufacturing.

Students are taught the basic principles of working with industrial robotic arms in the field of architecture. Students practice different concepts of robotic control, which enables them to execute basic routines. They are able to write their own programmes and directly control the robotic set-up using UR-Script and custom Python modules. Through multiple exercises, students learn how to design and robotically build small-scale spatial structures exhibiting the potential of robotic fabrication processes. Additionally, they employ simple feedback loops for improving the accuracy of the fabrication process and as design-drivers.

MAS in Architecture and Digital Fabrication - Key for Type

| O     | Compulsory | E- | Recommended, not eligible for credits |
| W+    | Eligible for credits and recommended | Z  | Courses outside the curriculum |
| W     | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V     | lecture | P | practical/laboratory course |
| G     | lecture with exercise | A | independent project |
| U     | exercise | D | diploma thesis |
| S     | seminar | R | revision course / private study |
| K     | colloquium |   |                         |

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Architecture, Real Estate, Construction

Core Courses

<table>
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<tr>
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<th>Hours</th>
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<tr>
<td>072-0001-00L</td>
<td>Construction Industry and Real Estate Market</td>
<td>O</td>
<td>3 credits</td>
<td>7G</td>
<td>A. Paulus, S. Menz</td>
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</table>

Abstract
In the first term of MAS ETH ARC, the students' knowledge of the construction sector and the real estate market will be reinforced and deepened, along for an informed interpretation of the stakeholders' decision making processes. It explores the topics of involved parties and perception of demand. Additionally, it will guide students in developing their research proposals and research questions.

Objective
The first term of MAS ETH ARC supports the students' expertise and personal skills and develops their reasoning and creative thinking skills. It compels the students to understand both ambitious projects and complex properties, to pursue long-term intentions, to carry out specific tasks, and to become aware of the consequences of their decisions. Over the course unit, students review and closely examine the expertise which they have gained so far. The course directs students to draw independent conclusions and to set forecasts as professionals. Ultimately, the knowledge and expertise which is gained throughout the unit will allow the students to fully realise their role as a professional in their field.

Content
In the first term of MAS ETH ARC, the students' knowledge of the construction sector and the real estate market will be reinforced and deepened, along for an informed interpretation of the stakeholders' decision making processes and interests. It also explores the topics of involved parties and perception of demand. Additionally, it will guide students in developing their research proposals and research questions.

Key words of the course unit
Project and property, design and building process, involved parties and services, interests, basic knowledge and terms, perception and dissociation, sustainable decisions, and life cycle

MAS thesis
Aiding students on potential research, in light of students' interests, work and academic experience, and their professional aims.
Assisting students with determining the relevance of the study area. Discourse, developing the research objectives and devising the research questions. Public presentation of the initial objectives.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Methodology

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<tr>
<th>Number</th>
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<tr>
<td>072-0003-00L</td>
<td>Methodology</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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</table>

Abstract
In the fourth term of MAS ETH ARC, the students will guide through the process of methodology which is the ability to put their attitude into practice. Additionally, the course unit puts emphasis on the research findings and finalisation of the written work.

Objective
The fourth term of MAS ETH ARC supports the students' attitude and practice and methodology. It compels the students to analyse issues and carry out solutions. Ultimately, the knowledge and expertise which is gained throughout the unit will allow the students to fully realise their role as a professional in their field.

Content
In the fourth term of MAS ETH ARC, the students will guide through the process of methodology which is the ability to put their attitude into practice. Additionally, the course unit puts emphasis on the research findings and finalisation of the written work.

Key words of the course unit
Objectives, methodology, research, analysis and interpretation, academic writing, text understanding, publishing

MAS thesis
Aiding students on potential research, in light of students' interests, work and academic experience, and their professional aims.
Assisting students with determining the relevance of the study area. Discourse, developing the research objectives and devising the research questions, illustration the methodology, defining the contents, publicising their thesis. Public presentation of the objectives.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Major in Digitalisation

Core Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>072-0101-00L</td>
<td>Module 1: Foundations of Digitalisation</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

Abstract
Key terms: Digital transformation is more than digitisation of existing processes and information

Objective
Independently of the building industry, Module 1 initially provides information about the characteristics of digitalisation through its principles and rules, enabling the participants to independently recognise the short-term and long-term changes that are resulting from it.

Content
The first module addresses the topic of digitalisation and digital transformation in a holistic sense. It is much more than converting documents into PDFs or using software. It is about transforming processes, resources and information into a consistent and efficient digital system to make life easier for employees and customers. This journey always involves change. From the perspective of other industries, we first build up a basic understanding and discuss the opportunities and risks.

How do the experiences of other industries help us? What can be derived from them? Why is BIM only a small part and why is the future of BIM not BIM?

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

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<tr>
<td>072-0102-00L</td>
<td>Module 2: Collaboration</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

Abstract
Key terms: “Behavior for Collaboration” - Structural questions on collaboration and the patterns of behaviour.

Objective
In Module 2, we break from the theoretical idea of a purely technology-based, better collaboration and look at the situation realistically in order to be able to understand and develop new solutions and requirements.

Content
The usual approach towards digital transformation is to train people to use new technologies. In contrary, we ask for the specific challenges and problems people have with change. We learn to understand viewpoints of different partners within building projects and new solutions to specific problems.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch
Module 3: Foundation of Automation

Objective

The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.

- Profession
- Ethos and ethic
- Organisational forms
- Role and tasks
- Attitude and practice

Content

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Lecture notes

Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Literature

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 4: Foundation of Value Creation

Objective

Using specific examples, Module 4 illustrates the foundations and versatility of building information modeling (BIM), enabling participants to deal with the concepts, applications and mechanisms involved.

Content

“Highway to hell or highway to haven” - the question of a clear and simple roadmap is always at the heart of a digital transformation. “Value creation” is a central goal. Digitalisation is often seen as a strategy from the productivity gap. The fourth module shows how strategic goals can be developed in a roadmap and implemented in practice and how the individual shareholders and stakeholders participate.

We learn to consciously look at the topic of added value and digital transformation from different perspectives. Collision checking and quantity take-offs (QTO) are very useful. But they are only basics when it comes to real value creation.

Lecture notes

Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Literature

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 5: New Business Modelle

Objective

As a final module, new business models are discussed and explored. Examples will be used to explore patterns and interfaces and to analyse what is needed today and in the future for a successful and sustainable development of the sector. How can innovative ideas move us forward? What can we learn from design thinking? Why is it important for people to have useful and understandable measurable values? How do the 17 Sustainable Goals influence our industry?

Content

We will analyse the topic on the basis of two concrete examples, familiarise ourselves with them and observe their further development as a result.

Lecture notes

Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature

Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Term Paper

The Term Paper is offered in spring semesters only.

Major in Project Leadership

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>072-0201-00L</td>
<td>Module 1: Understanding of Roles</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<td>Only for CAS ARC in Digital and MAS in Architecture, Real Estate, Construction.</td>
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<tr>
<td>072-0202-00L</td>
<td>Module 2: Collaboration</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<td>072-0203-00L</td>
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<td>1</td>
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<td>A. Paulus, S. Menz</td>
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Key words: construction and real estate market, micro and macro environment

A. Paulus

Module 4: Guiding/Steering/Leading

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Key words: Bauwerk Schweiz, new construction and renovation, economy

S. Menz

Module 5: Project

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Key words: Team performance, due diligence and duty of loyalty, duties and tasks, liability, working packages, management and coordination

S. Menz

Term Paper

The Term Paper is offered in spring semesters only.

Major in Real Estate Strategies urban-peri-urban

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>072-0301-00L</td>
<td>Module 1: Perception of Demand</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>S. Menz</td>
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| 072-0302-00L | Module 2: State of the Art                          | W    | 1    | 2G    | S. Menz   |
|              | Does not take place this semester.                  |      |      |       |           |
|              | Only for CAS ARC in Real Estate Strategies urban-   |      |      |       |           |
|              | peri-urban and MAS in Architecture, Real Estate,    |      |      |       |           |
|              | Construction.                                       |      |      |       |           |
|              | Abstract                                            |      |      |       |           |
|              | Key words: Bauwerk Schweiz, new construction and    |      |      |       |           |
|              | renovation, economy                                |      |      |       |           |
|              | Objective                                           |      |      |       |           |
|              | Change in value, demolition / replacement, potential|      |      |       |           |
|              | for compression                                     |      |      |       |           |
|              | Content                                             |      |      |       |           |
|              | With more than CHF 3'585 billion (excluding land),  |      |      |       |           |
|              | Switzerland is the largest national capital. It     |      |      |       |           |
|              | grows by around 4.7 per cent each year, but         |      |      |       |           |
|              | its value is under-invested. Is there a risk of     |      |      |       |           |
|              | slippage? Should more be invested in maintenance /  |      |      |       |           |
|              | repair or more canceled and replaced? How big is    |      |      |       |           |
|              | the compaction potential in the stock? Excursus on  |      |      |       |           |
|              | civil engineering and infrastructure construction   |      |      |       |           |
|              | Lecture notes                                       |      |      |       |           |
|              | Literature recommendations at www.bauprozess.arch   |      |      |       |           |
|              | ethz.ch and www.kompetenz.arch.ethz.ch              |      |      |       |           |
|              | Literature                                          |      |      |       |           |
|              | Literature                                          |      |      |       |           |
|              | Literature                                          |      |      |       |           |
|              | Literature                                          |      |      |       |           |
|              | Literature                                          |      |      |       |           |

| 072-0303-00L | Module 3: Economic Interest                        | W    | 1    | 2G    | S. Menz   |
|              | Does not take place this semester.                  |      |      |       |           |
|              | Only for CAS ARC in Real Estate Strategies urban-   |      |      |       |           |
|              | peri-urban and MAS in Architecture, Real Estate,    |      |      |       |           |
|              | Construction.                                       |      |      |       |           |
|              | Abstract                                            |      |      |       |           |
|              | Key words: intention development, realization       |      |      |       |           |
|              | operation                                           |      |      |       |           |
|              | Objective                                           |      |      |       |           |
|              | The participants understand a property in the       |      |      |       |           |
|              | context of a life cycle                             |      |      |       |           |
The aim is to become familiar with the tools used in marketing and able to use them in specific situations.

The various depths of intervention in dealing with an existing property and their effects are known.

Module 1: Market

A. Paulus

Marketing means orienting company activities towards market demands. Communication between suppliers, clients and the competition.

The aim is to become able to analyse and implement the processes and instruments used for acquisition in one's own company.

The importance of a life-cycle-oriented approach has arrived in the Swiss construction and real estate sector. Cumulative management.

Module 4: Financial Management

A. Paulus

1 credit

The structure and nomenclature of the interventions in the stock are presented and models for the registration and calculation of the

ECTS: 1 credit

2G

S. Menz

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 5: Life Cycle and Resources

A. Paulus

1 credit

The total weight of all properties in Switzerland is estimated at around 1 billion tonnes. Every year around 10 million m³ of buildings are demolished and more than 60 million t of raw materials are used in new buildings. This module examines the cycle principle and its implications for selective decommissioning, disposal, landfilling, recycling and reuse, as well as the importance of the gray matter energy of materials.

Literature

S. Menz

Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 3: Marketing

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 2: Acquisition

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 1: Market

A. Paulus

1 credit

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1 credit

A. Paulus, S. Menz

Literature

Module 4: Financial Management

A. Paulus

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A. Paulus, S. Menz

Literature

Module 5: Life Cycle and Resources

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Module 5: Life Cycle and Resources

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Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 2: Acquisition

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 1: Market

A. Paulus

1 credit

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1 credit

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Literature

Module 4: Financial Management

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 5: Life Cycle and Resources

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 3: Marketing

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 2: Acquisition

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 1: Market

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 4: Financial Management

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature

Module 5: Life Cycle and Resources

A. Paulus

1 credit

Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.

1 credit

A. Paulus, S. Menz

Literature
Abstract
Key terms: Cost accounting, budgeting and controlling

Objective
The aim is to become able to analyse one’s own company’s financial resources in detail, interpret key parameters for the current situation and test them.

Content
Financial management means achieving the target company output with costs that are as low as possible, and in the longer term to create secure asset and capital structures. The tasks involved in financial management in a planning office include establishing a well-structured accounting department, careful cost accounting, sound budgeting and an effective controlling system. On the basis of a practical financial structure for architecture and engineering offices, the “financial management” module presents the information needed to carry these tasks out in a professional and responsible way.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

072-0405-00L Module 5: Digitalisation
Only for CAS ARC in Unternehmensführung and MAS in Architecture, Real Estate, Construction.

Abstract
Key terms: Strategy, potentials and digital planning

Objective
The aim is to become familiar with the current practical work involved in IT in planning companies and be able both to analyze the specific challenges it implies and also to infer one’s own prospects for development in this context. In addition, thought needs to be given to the way in which the value creation provided by digitalisation influences one’s own company.

Content
IT refers on the one hand to information and data processing in a company, and on the other to the hardware and software components needed for the purpose. This “information technology” module focuses on potential strategies for company management in the IT field. The focus is not on the use of any individual programme, but on taking conscious decisions for or against IT components in one’s own company in order to obtain helpful support in one’s everyday work. The strengths, weaknesses, opportunities and risk of this strategy suggest possible potentials.

The participants will present their own theses on entrepreneurship and open them up for discussion in the plenary session.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Term Paper
The Term Paper is offered in spring semesters only.

MAS in Architecture, Real Estate, Construction - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
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<td>Courses outside the curriculum</td>
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Key for Hours

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<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Core Courses and Seminars

<table>
<thead>
<tr>
<th>Number</th>
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<td>079-0100-00L</td>
<td>Seminar Basics</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>S. Langenberg</td>
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<td></td>
<td>Only for CAS in Preservation and MAS in Preservation and Construction History</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>The seminar provides an introduction to the basics of scientific work. It imparts methods of architectural and cultural studies, introduces participants to archival research and enables them to critically and analytically evaluate the sources consulted. Forms of communicating scientific results are also a topic of the seminar.</td>
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<td>The aim of the seminar is to qualify participants to apply methods of architectural and cultural studies in the evaluation of objects of the built environment. Participants are enabled to assess a building which they have selected in the form of a heritage conservation report.</td>
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<tr>
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<td>Content</td>
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<td>An essential basis for a responsible engagement with the built heritage is the ability to recognize its characteristics and peculiarities from an architectural scientific point of view, and to objectively elaborate on them. For this, knowledge of scientific methods is just as much a prerequisite as the ability to undertake purposeful research and to critically evaluate source material in order to productively include it in the analysis. The first part of the seminar is devoted to an introduction to scientific work in the fields of architectural and cultural studies. This lays the foundation for the second part, which deals with the independent scientific evaluation of a building which the participants choose individually.</td>
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| 079-0101-00L | Seminar Texts on Preservation | O    | 3    | 2S    | R. Rehm, S. Langenberg |
|             | Only for CAS in Preservation and MAS in Preservation and Construction History |      |      |       |                 |
|             | Abstract                       |      |      |       |                 |
|             | In the seminar, selected texts on architectural theory and monument preservation are read together and discussed in plenary. The focus is on selected writings from John Ruskin, Gottfried Semper and Friedrich Nietzsche to Alois Riegl and Adolf Loos to Walter Benjamin, Aleida Assmann and Peter Zumthor. |      |      |       |                 |
|             | Objective                      |      |      |       |                 |
|             | Skills in reading complex theoretical and literary writings on architecture and monument preservation are taught. With increasing practice, these enable participants to undertake an independent appropriation of architectural theory and monument preservation content. |      |      |       |                 |
|             | Content                        |      |      |       |                 |
|             | The writings on architectural theory and historic preservation discussed in the seminar provide an overview of the most important theories and concepts of historic preservation. Ruskin’s narrative of architectural historicity, Semper’s conception of “Bekleidung” and Nietzsche’s transformation of mythology are covered, as are Riegl’s notions of “Erinnerungswert” and “Gegenwartswert”, Loos’ writings on architecture, Benjamin’s notion of aura and Aleida Assmann’s memory space as well as Peter Zumthor’s atmosphere. Each text is discussed in terms of textual structure, conceptual history, visual language, relationship to poetry and literature, strategies of theory, etc. Identifying the levels and intersections that link a theory with other theories characterises one of the main tasks of our seminar. |      |      |       |                 |
|             | Literature                     |      |      |       |                 |
|             | Georg Dehio, Kunsthistorische Aufsätze, Munich 1914. |      |      |       |                 |
|             | Uta Hassler/Winfried Nerdinger, Das Prinzip der Rekonstruktion, Zurich 2010. |      |      |       |                 |

| 063-0911-22L | Future Monuments | O    | 2    | 2V    | S. Langenberg |
|             | Only for CAS in Preservation and MAS in Preservation and Construction History |      |      |       |                 |
|             | Abstract                       |      |      |       |                 |
|             | Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice. |      |      |       |                 |
|             | Objective                      |      |      |       |                 |
|             | In addition to active participation in the discussions, students will be asked to engage with a topic or object of their own choice in order to be able to develop and comprehensively justify their own positions within the context of preservation. Our goal here is to foster students’ communication skills and the culture of discussion. |      |      |       |                 |
|             | Content                        |      |      |       |                 |
|             | The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. This core conveys this knowledge to students with the help of selected writings and discussions in the context of various guest lectures. In addition to dealing with historical buildings, the course is also dedicated to younger (and very young) objects and inventories - for in addition to the preservation of already listed objects, the selection and inventory of future protected objects is also one of the core tasks of heritage conservation. |      |      |       |                 |
Literature

READING LIST

Monographs and edited volumes:


Dehio, Georg, Kunsthistorische Aufsätze. München 1914


Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohlleben, Marion und Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:


Die Kunstdenkmäler der Schweiz

INSA – Inventare der Heimatkantone der Teilnehmenden
The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a "monument", structural-legal

ECTS


In addition to elaborating the legal concept of monuments, the course familiarises participants with legal protection instruments and

Content

The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a "monument", structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with the procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer's (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zürich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.

079-0151-00L Theory and History of Preservation in the German-speaking Realm

Only for CAS in Preservation and MAS in Preservation and Construction History

Abstract

The course provides an overview of theory formation in heritage conservation. The focus is on European history and German-language texts.

Objective

The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation from antiquity to the 21st century, and to contrast the different approaches to thought and their development

Content

In order to get to know the formation of theory, its paths and detours, the most important terms and persons in the history of monument conservation are introduced. Based on various texts, the history of the protection of architectural monuments since antiquity is illuminated. Further focal points in the history of monument preservation were during the Enlightenment, the French Revolution and in the process of the formation of nation states. The discourse on the concept and practice of monument conservation as we understand it today was led by a number of conservators in the German-speaking world around 1900. War-related destruction and the incipient building boom in Europe led to modern debates on the theory of monuments, which are still relevant today. Dealing with monument values is not an end in itself; it can be essential for the preservation of the monument or for historical mediation. Critical positions on the tasks, goals or practices of heritage preservation can only be developed against the background of a knowledge of its historical approaches.

Literature

Leo Schmidt, Einführung in die Denkmalpflege, Darmstadt 2008.
Gottfried Kiesow, Einführung in die Denkmalpflege, Darmstadt 2008.

To follow

Autumn Semester 2022
This lecture series deals with the history of the production of buildings. This history draws heavily on pictorial and archival sources, but the lecture will always establish the link to traces observable on site. In that sense, the lecture is an introduction to the wide topic of "building archeology". Among others, we will cover the following topics:

- construction materials, tools and tooling of construction elements
- material flow and economic boundary conditions of the construction site
- construction site technology and construction machinery (scaffolding, cranes, etc.)
- historic methods of architectural planning
- history of building production

This lecture is closely related to current research projects.

Lecture notes

PDFs of the lecture slides will be provided before the lecture. Furthermore, the audience will be granted access to recent journal articles and book chapters providing in-depth insight into the topics covered by the lecture.

Taught competencies

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<td>Techniques and Technologies</td>
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<td>Self-awareness and Self-reflection</td>
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Additional Major Courses and Cooperations

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>052-0913-22L</td>
<td>Preservation: A Future for whose Past?</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>S. Langenberg</td>
</tr>
</tbody>
</table>

ITA Pool Introduction to courses within the institute ITA:
7.9.22, 10-11h, HIB Open Space.

Abstract
A Future for Whose Past? The focus is on the heritage of minorities, marginalised groups and people without a lobby. This rarely considered heritage will be explored theoretically and practically through excursions, meetings and readings. The aim is to develop a concept and mediation formats for an international exhibition in 2025, the 50th anniversary year of the European Heritage Year 1975.

Objective
The students gain insight into the most important theories and practices of monument preservation and ways of conveying and exhibiting them. Through the examination of a self-selected topic, questions can be deepened and discussed in the group. The learning objectives in this semester are critical questioning of heritage and inventory, strengthening of mediation skills and the consideration of architecture and urban development in cultural-historical, sociological and economic perspectives.

Content
In monument preservation, too, the existence of a "mainstream" and a lack of inclusion have been criticised. This is particularly visible in the post-colonial UNESCO World Heritage status of 1,154 sites, of which only about a hundred are in Africa, but almost 600 are in Europe. But at the national level, too, there is a need to discuss whether the sites protected by monument, nature and heritage conservation laws in the German-speaking and thus preserved for the future actually represent history and the past. Whose heritage are we talking about, who determines what is important for society's memory and with which heritage a society identifies?

In the autumn semester of 2022, we will devote ourselves to the heterogeneity of the architectural heritage and critical approaches to monument preservation. Innovative methods and interfaces of public mediation will be investigated and applied. The insights gained will flow into the conception and development of the exhibition.

Literature


Gender and Heritage. Performance, Place and Politics, ed. by Wera Grahn and Ross J. Wilson, London/New York 2018
Abstract
Surveying and measuring technologies in historical building archaeology.

Objective
Basic understanding of different surveying methods and first practical contacts with technical surveys instruments.

Content
From folding rule to laser scanner: surveying techniques and their possible applications.

The elective subject “Methods of Building Surveying” covers surveying and measurement methods ranging from simple hand measurements and tachymetry to laser scanning, terrestrial and drone-based photogrammetry (structure from motion) and other non-invasive assessment methods such as thermal imaging. The different methods and technologies will be presented on the basis of current or completed research projects and their practical applications will be discussed. Internal and external guest speakers will report on their latest research projects in the field of building research and construction history. In the course of the elective, students will also have the opportunity to try out the methods themselves and integrate them into a small concluding project of their own.

The course is composed of theoretical and practical parts in and outside the classroom.

Will be announced in the course for the individual lectures.

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Electives

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<tr>
<td>052-0705-00L</td>
<td>Landscape Architecture I</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>C. Girot</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the history and theory of garden design and landscape architecture. Analysis of the design of historical gardens and landscapes within the cultural background.

Objective
The course covers the basic history and theory of garden design and landscape architecture from its beginnings to the 21st century. The course aims to raise awareness of a changing perception of nature and landscape.

Content
The lecture series on History and Theory of Garden Design and Landscape Architecture deals with the historical development of designed nature, from the beginnings of cultural landscapes and gardens to 21st century landscape architecture. In the analysis of each era, the focus is on the spatial and cultural relationship between the garden, the city and the landscape, as well as the changing perceptions of nature and its representation.

Lecture notes
Handouts and a reading list will be provided.

Literature
A reading list will be provided for the exams.
General Information for the final exam:
Bachelor students: The content of the lectures as well as texts and exam-relevant literature provided by the Chair make up the basis for preparing for the exam. The lecture series is conceived as a yearlong course. Since the written session examination will test knowledge from both semesters, it is necessary to fully attend the lectures of both courses “Landscape Architecture I” and “Landscape Architecture II”. The themes of the examination will be announced at the end of the semester. The Chair will provide literature and texts available for download as pdfs. These allow a more in-depth understanding of the lecture material.
Exchange students or students from other departments: Students, who are attending only one semester, may pass the oral end-of-semester examination. Test-relevant literature will also be made available for download for this purpose. The students are requested to get in touch by email with the Chair.

052-0901-00L Building History I W 2 credits 2V S. Holzer

Abstract
History of building from classical antiquity to modernity: building types, constructions, forms, with particular reference to functional issues such as flexibility of use, statics, durability. This is not a mere history lecture, but an important part of the basic introduction into construction.

Objective
Participants know the fundamentals of building history, including landmark monuments of each era, key historic constructions and forms. They are able to “read” a historic building and to relate it to building history. They are aware of the variety of historic building constructions.

Content
Building history I covers the period from classical Greek antiquity to Gothic architecture. The principal topics include construction issues such as Greek megalithic building, Roman mortar-and-rubble construction, and Gothic rationalism of vaulted architecture.

Within the Vitruvian and Albertian triad of firmitas, utilitas and venustas, we focus on the first two topics, whereas the last topic (deciphering the “meaning” of architecture) stands at the heart of the “architectural history” lectures. The present lecture contributes essentially to deepening knowledge about historic constructions, an indispensable precondition for building within existing fabric.

Lecture notes
Please keep a tight record of manuscript notes yourself. Lecture notes to some topics will be provided. pdf of lecture slides will be on line before each lecture.

Literature
Will be announced during the lectures.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
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Mas in Preservation and Construction History - Key for Type

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<tr>
<td>W</td>
<td>Eligible for credits</td>
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Key for Hours

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<th>lecture</th>
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<td>lecture with exercise</td>
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<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>colloquium</td>
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| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## MAS in Digital Clinical Research

### Mandatory Modules

#### Module Modern Concepts in Clinical Research

<table>
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<tbody>
<tr>
<td>395-0100-00L</td>
<td>From Clinical Problem to Research Question</td>
<td>O</td>
<td>1.5 credits</td>
<td>2G</td>
<td>S. Goldhahn, A. Frotzler, J. Steurer</td>
</tr>
<tr>
<td>395-0101-00L</td>
<td>Modern Study Concepts</td>
<td>O</td>
<td>1.5 credits</td>
<td>1G</td>
<td>A. Burden, S. Goldhahn, to be announced</td>
</tr>
<tr>
<td>395-0102-00L</td>
<td>Real-World Data</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>K. Crameri, C. Jutzeler, S. Österle</td>
</tr>
<tr>
<td>395-0103-00L</td>
<td>Precision Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>S. Modica, A. Ghosh, C. Wolfrum</td>
</tr>
</tbody>
</table>

### Compulsory Elective Modules

#### Module Regulatory Thinking

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>395-0200-00L</td>
<td>Introduction Regulatory World</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>to be announced</td>
</tr>
<tr>
<td>395-0201-00L</td>
<td>Regulatory Thinking</td>
<td>W</td>
<td>3 credits</td>
<td>4G</td>
<td>to be announced</td>
</tr>
<tr>
<td>395-0202-00L</td>
<td>Intended Use / Indication</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>to be announced</td>
</tr>
<tr>
<td>395-0203-00L</td>
<td>Production / GMP</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>to be announced</td>
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#### Module Nutrition in Medicine

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>395-0300-00L</td>
<td>Introduction to Nutrition</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>F. von Meyenn, I. Herter-Aeberli, J. Rigutto</td>
</tr>
<tr>
<td>395-0301-00L</td>
<td>Digital Nutrition Monitoring</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>I. Herter-Aeberli</td>
</tr>
<tr>
<td>395-0302-00L</td>
<td>Nutrition in Metabolic Disease</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Wolfrum, F. von Meyenn</td>
</tr>
</tbody>
</table>

### Master's Thesis

Wird ab HS 2023 angeboten

---

**MAS in Digital Clinical Research - Key for Type**

- **O**: Compulsory
- **W⁺**: Eligible for credits and recommended
- **W**: Eligible for credits

**Key for Hours**

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium

<table>
<thead>
<tr>
<th>ECTS</th>
<th>Practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
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</table>

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>independent project</td>
</tr>
<tr>
<td>R</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>E⁻</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td></td>
<td>Courses outside the curriculum</td>
</tr>
</tbody>
</table>

Special students and auditors need special permission from the lecturers.
# MAS in Development and Cooperation

The compulsory courses of NADEL are accessible only for students of the MAS in Development and Cooperation and for qualified employees with at least two years experience in development cooperation and a Master's level or equivalent level of education as recognized by ETH. PHD students doing empirical research in development cooperation may be admitted "sur Dossier". The elective courses are open to master students of the ETH with registration/ waiting list. MAS students do have priority.

▶ **Advanced Training Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>865-0065-00L</td>
<td>VET between Poverty Alleviation and Economic Development</td>
<td>W</td>
<td>2</td>
<td>3G</td>
<td>K. Hartgen, F. Kehl, M. Maurer</td>
</tr>
<tr>
<td></td>
<td>Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation.</td>
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<tr>
<td></td>
<td>ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.</td>
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<td></td>
<td>Registration only through the NADEL administration office.</td>
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</tbody>
</table>

**Abstract**
The course aims at strengthening the capacity in portfolio management for VET, skills development and active labor market policies. It deals with basic issues and challenges of Vocational Education and Training (VET) in Developing Countries. In view of the many of school leavers VET has to place itself between the contradicting intensions of quality education and short-term training interventions.

**Objective**
The participants are able to
- Assess project proposals and ongoing project regarding their relevance and suitability in the specific country context
- Explain strengths and weaknesses of the opposing approaches "dual apprenticeship" and "competency based training" as well as synergies and incompatibilities between the two
- Describe the competent use of tools currently applied in VET

**Content**
- Basic concepts and terms
- Differences and commonalities between VET and neighboring systems
- Planning, assessment of VET interventions with different objectives: economic development, poverty alleviation, creation of self-employment or systems development
- VET as a cooperation system of stakeholders with different duties, interests and competencies
- Background, potential use and limitations of (national) qualification frameworks
- Half-day visit to important actors of the Swiss VET landscape

**Prerequisites / notice**
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariate.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>865-0064-00L</td>
<td>Decolonizing Aid</td>
<td>W</td>
<td>2</td>
<td>3G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
<td></td>
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<td></td>
<td>Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation.</td>
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<tr>
<td></td>
<td>Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted &quot;sur Dossier&quot;.</td>
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<td></td>
<td>Registration only through the NADEL administration office.</td>
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</tbody>
</table>

**Abstract**
The course is designed to increase awareness of how cultural perceptions and power structures have influenced society and our understanding of and practice in aid. It promotes alternatives to aid as linear and progressive Eurocentric narrative. The course draws on different theoretical perspectives and scrutinizes practical examples of aid interventions and similar initiatives.

**Objective**
The course goes beyond awareness raising of personal cultural characteristics and recognizing cultural values within development concepts. It unfolds traces of colonialism and power structures in day to day live and the aid industry. It promotes searching and initiating alternatives to aid as a Eurocentric narrative. Participants get familiar with different theoretical perspectives on decoloniality and scrutinize practical examples of aid interventions and similar initiatives.

**Content**
- Decoloniality key terms and concepts
- Conceptions of and alternatives to development (cooperation)
- Cultural (self-) awareness, diversity
- The role of culture in aid / development cooperation
- Implications of decolonialism for aid policy making and practice

**Prerequisites / notice**
Students of the course must fulfill requirements specified on the homepage of NADEL.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>865-0070-00L</td>
<td>The Private Sector and Development Organizations: Building Successful Alliances</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td></td>
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<tr>
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<td></td>
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<td>Registration only through the NADEL administration office.</td>
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</tbody>
</table>

**Abstract**
The following topics will be discussed: The political economy of the Corporate Social Responsibility discourse, voluntary governance regimes and development; theory of change and effectiveness of soft law approaches, PPPs: introducing concepts and taking stock of experience, analysis of private sector strategies from selected governance actors, engaging with the private sector.

**Objective**
This course seeks to increase the participants’ understanding of the multifaceted and dialectic relationships between civil society, governments and private sector. It equips participants with knowledge and tools required for a strategic interaction between private sector organizations and development agencies. The course enables participants to contribute effectively to policy debates on the role of private sector actors and development.

**Prerequisites / notice**
Students of the course must fulfill requirements specified on the homepage of NADEL.
Socio-cultural Aspects of Development

Development Economics
K. Schneider

Assessed Analytical Competencies
Lecturers

The course examines forms, causes and effects of fraud and corruption in developing countries. Participants receive an introduction to the main concepts and mechanisms of prevention, detection, investigation and sanctioning. By using practical examples, the course prepares participants for dealing with fraud and corruption related issues in the context of development projects.

Objective Participants are able to describe and reflect on different forms, causes and effects of fraud and corruption in the context of development cooperation. Based on common concepts and mechanisms of the international community they are able to apply and differentiate prevention, detection, investigation and sanctioning of fraud.

Study Semester

Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>865-0003-00L</td>
<td>Development Economics ▪</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>K. Harttgen, I. Günther</td>
</tr>
</tbody>
</table>

Abstract
This course is an introduction to theoretical and empirical discussions on economic development, with a focus on the challenges of developing countries over the last 50 years. The course provides answers to the following questions: How can and should development be measured? What factors drive economic growth and contribute to poverty reduction?

Objective
Students are able to:
- critically discuss economic questions in the context of developing countries
- critically discuss policy recommendations for economic development.

Content
- measurement of development, poverty and inequality,
- growth theories
- trade and development
- education, health, population and development
- states and institutions
- economic policies for economic growth and poverty reduction
- economics of development aid

| 865-0007-00L | History and Forms of International Development Cooperation | O    | 3 credits | 3G    | K. Schneider |

Abstract
This course presents the origins and evolution of the International Development Cooperation during the last six decades and relates the changing paradigms to their political and socio-economic contexts. It looks at the different actors with their specific roles, approaches and challenges from a Swiss perspective.

Objective
The students are able to:
- analyse the evolution of the International Development Cooperation, selected development theories and their practical application in the historic context
- describe the Swiss landscape of actors in Development Cooperation and its integration into the International community of donors.
- assess possible implications of the Agenda 2030 for the structure and practice of the International cooperation

Content
- History of International Development Cooperation: beginnings, change of development theories over time
- International efforts to increase sustainability and aid effectiveness
- Swiss bilateral agencies for development: SDC and SECO
- Multilateral development banks: Bretton Woods Institutions
- Non-governmental Organisations: Challenges today - in Switzerland and in partner countries
- Economy, private foundation and philanthropy: New actors with high aspirations
- Humanitarian Aid between intervention in crises, prevention and development tasks

| 865-0010-00L | Politics and Governance                                       | O    | 2 credits | 2G    | F. Brugger |

Abstract
The course focuses on selected issues of governance systems in developing countries, and on possible interventions of development cooperation to improve the quality of governance.

Objective
The students are able to:
- describe the current status and threats of natural resource use and environmental degradation
- portray the management of natural resources such as land, forest, water, and biodiversity in different contexts and discuss the key challenges in each sector
- examine the implications of climate change on development and the sustainable management of natural resources
- analyse conflicts and trade-offs between environmental resource use and economic development
- discuss the global priorities relating to human-induced changes to the environment, and how these can be met

Taught Competencies

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Cooperation and Teamwork
- Personal Competencies: Critical Thinking

| 865-0010-01L | Environment, Natural Resources and Climate Change             | O    | 3 credits | 3G    | J. Neve |

Abstract
Degradation of the environment and non-sustainable use of natural resources, including land, water, forests and biodiversity is threatening individual livelihoods as well as local, national and international economies. This lecture series will address conflicts related to unsustainable resource use and discuss trade-offs between environmental sustainability and economic development.

Objective
The student will be able to:
- describe the current status and threats of natural resource use and environmental degradation
- portray the management of natural resources such as land, forest, water, and biodiversity in different contexts and discuss the key challenges in each sector
- examine the implications of climate change on development and the sustainable management of natural resources
- analyze conflicts and trade-offs between natural resource use and economic development
- discuss the global priorities relating to human-induced changes to the environment, and how these can be met

Taught Competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Cooperation and Teamwork
- Personal Competencies: Critical Thinking

| 865-0001-00L | Socio-cultural Aspects of Development                          | O    | 3 credits | 3G    | K. Schneider, M. Malefakis |

Abstract
In this course, central development issues are discussed from a historical, sociological, and anthropological perspective. Themes such as decolonization, migration, gender, racism, religion and education are used to shed light on one's own Western ideas and critically reflect on their influence on the design of interventions in development cooperation.
Objective
- The students will be able to:
  - consider which social, cultural and psychological factors influence human action, and discuss their importance for development cooperation
  - explain different conceptions of development in Western and non-Western cultures and indicate possible consequences for development projects
  - display basic knowledge of selected topics on social and cultural development

Content
- Raising awareness on selected cultural and social aspects of development issues and their relevance for development cooperation (DC):
  - Importance of the concept of “culture” in DC
  - Colonialism, decolonization and its consequences
  - Promotion of education systems
  - Role of religion in development interventions
  - Migration - challenges and opportunities
  - Cross-cutting issues in DC: gender and disability
  - Art and peacebuilding

Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>865-0010-02L</td>
<td>Food Security and Agriculture</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>S. Patel</td>
</tr>
<tr>
<td></td>
<td>Students of the MAS ETH in Development and</td>
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</tr>
<tr>
<td></td>
<td>Cooperation have priority. Interested students can place themselves on the waiting list and will be informed about a possible admission by the course coordinators within the first week after the start of lectures.</td>
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</tbody>
</table>

Abstract
- Food security has been on top of the policy agenda for decades, but still a considerable proportion of the population in developing countries remains hungry and malnourished. This lecture series will explore how we produce and distribute food; analyse the concept of food security and discuss ways and means for increasing the availability and accessibility of food in developing countries.

Objective
- The student will be able to:
  - describe the most important milestones in the history of food and agriculture
  - understand the concept of food security and discuss causes and impact of food insecurity
  - compare different approaches to promote and increase crop- and livestock production in a sustainable manner
  - reflect on some of the main economic challenges of the world food system and understand some of the tradeoffs between smallholders’ decisions of labor, consumption, and production of food
  - give insights in how international organizations work with farmers and governments in developing countries to ensure availability and equal access to food


Abstract
- The course provides an overview of the links among sanitation, water supply, waste management and environmental and health aspects. It gives an understanding of the specific challenges and possible solutions in ensuring environmental services and illustrates their impact on the population and settlements.

Objective
- The participants are able to:
  - present the global situation and development trends in the sector of sanitation, water supply, waste management and for its main actors;
  - discuss the relationships between water supply, sanitation and health;
  - explain the principles of technologies for drinking water treatment, the management of sewage and waste, as well as appraise their strengths and weaknesses;
  - explain which sustainable concepts are implemented and how they can be inserted into the technical, institutional and social structures so that they are economically, ecologically and socially sustainable;
  - provide information where good professional resources are available.

865-0068-00L  Justice and Normative Aspects of Development  W  2 2G

Abstract
- This course discusses ethical questions of development relevant for international cooperation. Examples include: possibilities and limits of normative justification of development aid; theories of justice, human rights and the 'rights-based' approach to development, epistemological foundations of development theories, ethical questions of globalization.

Objective
- What is justice and why are human rights valid? What is development and what is the responsibility of the State? The answers always include normative judgements. Where these normative dimensions remain implicit, international development cooperation risks the unreflected export of its own value and belief systems. This course enables students to identify implicit normative dimensions, put them into the ethical context and to critically reflect on those normative aspects.

865-0069-00L  Health and Development  W  2 2G  K. Harttgen

Abstract
- The following topics will be discussed: Basic principles of epidemiology and global burden of disease distribution, Health systems and health system strengthening including economic aspects and health insurance, communicable diseases such as HIV/AIDS, Malaria, tuberculosis and neglected tropical diseases, mother and child health, non-communicable diseases and transition in health in LAMICs.

Objective
- This course aims at providing a public health driven overview on most important topics related to health and health care in low- and middle-income countries (LAMICs). After the module participants shall have broad understanding of challenges for health, health care and health systems in LAMICs. They shall be able to discuss more in depth some major global health topics, such as health systems, transition in health, malaria, neglected tropical diseases and HIV/AIDS. The course will provide an insight into current strategies and approaches addressing major global health topics.

865-0008-00L  Policy Evaluation and Applied Statistics  W  3 2G  I. Günther, K. Harttgen, K. Schneider

Abstract
- This course introduces students to key methods for quantitative policy impact evaluation and covers the different stages of the research process. Acquired skills are applied in a self-selected project applying experimental methods. Students also learn how to perform simple statistical analyses with the statistical Software R.

Objective
- Students
  - know strategies to test causal hypotheses using experimental methods and regression analysis.
  - are able to formulate and implement a research design for a particular policy question and a particular type of data.
  - are able to critically read and assess published studies on policy evaluation.
  - are able to use the statistical software R for data analysis.
  - can apply all the steps involved in a policy impact evaluation.
Policy impact evaluation employs a wide variety of research methods, such as statistical analysis of secondary data, surveys or laboratory and field experiments. The course will begin with an overview of the various methodological approaches, including their advantages and disadvantages and the conditions under which their use is appropriate. It will continue with a discussion of the different stages of a policy impact evaluation, including hypothesis generation, formulating a research design, measurement, sampling, data collection and data analysis. For data analysis, linear regression models will be revised, with a focus on difference-in-difference methods, regression discontinuity design and randomized controlled trials used for policy evaluation. Students, who already have a solid background in these methods can skip these sessions.

Throughout the course, students will work on a self-selected project on a suitable topic. In addition, students will have to solve bi-weekly assignments.

Semester Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>865-0700-00L</td>
<td>Semester Thesis</td>
<td>O</td>
<td>4 credits</td>
<td>9A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only for MAS in Development and Cooperation.

Abstract

The students work on a question in multidisciplinary groups applying theory-based approaches and sound methods. The results are discussed with experts and policymakers. The thesis is a literature study with a strong application-oriented or empirical character based on scientific publications, expert opinions and reports from organizations. The work may also include limited information surveys.

Objective

- Practice scientific collaboration in a multidisciplinary team
- Apply themselves to a development topic in order to address policy relevant questions
- Present and discuss study results and policy implications in front of different audiences

MAS in Development and Cooperation - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
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<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### MAS in Nutrition and Health

#### Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Puhun, R. Heusser</td>
</tr>
<tr>
<td>Abstract</td>
<td>The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.</td>
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<tr>
<td>Objective</td>
<td>The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.</td>
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<tr>
<td>Content</td>
<td>The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.</td>
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<td>Taught</td>
<td>Subject-specific Competencies</td>
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<tr>
<td>752-2307-00L</td>
<td>Nutritional Aspects of Food Composition and Processing</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>B. E. Baumer, J. M. Sych</td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.</td>
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<tr>
<td>Objective</td>
<td>Students should be able to apply basic knowledge of biochemistry, physiology, and nutrition to the evaluation of the nutritional quality of food.</td>
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<td>Content</td>
<td>The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, emerging technologies) or major formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.</td>
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<tr>
<td>Lecture notes</td>
<td>There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.</td>
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<tr>
<td>752-6301-00L</td>
<td>Nutrition-Related Physiology</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>F. von Meyenn, E. Gasser</td>
</tr>
<tr>
<td>Abstract</td>
<td>Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand.</td>
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<td>Objective</td>
<td>Students are expected to apply basic knowledge of biochemistry, physiology, and nutrition to the evaluation of the nutritional quality of food.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts for each lecture will be uploaded to Moodle every week.</td>
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<tr>
<td>766-6205-00L</td>
<td>Nutrient Analysis in Foods</td>
<td>W+</td>
<td>3 credits</td>
<td>3U</td>
<td>J. Rigutto</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this practical course, different meals are prepared and then analysed for nutritional content in the laboratory. The analyses comprise energy, macronutrients and specific micronutrients, as well as polyphenols and phytic acid. Based on these results, the nutritional value of each meal is critically evaluated and discussed.</td>
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<tr>
<td>Objective</td>
<td>The objectives of this practical course include learning about and experience with analytical methods to determine macro- and micronutrient content in foods, critical evaluation of analytical results, critical comparison with values from food composition tables, and interpretation in relation to nutritional value of meals.</td>
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<tr>
<td>Content</td>
<td>The practical course Nutrient Analysis in Foods includes meal preparation (a half day early December 2022; date to be defined) and chemical analysis of five meals from 5 different types of diets (students will work in groups; one meal per group). The content of macro- and micronutrients, specific micronutrients and secondary plant components (polyphenols and phytic acid) are analysed using common analytical methods. The analytical results are compared with calculated data from food composition databases using the nutrition software EbisPro and then critically evaluated.</td>
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<tr>
<td>Lecture notes</td>
<td>The practical course is accompanied by lectures on the basic principles of analytical chemistry that will be made available via Moodle. The cooking and laboratory methods will be described in a &quot;script&quot; which will be made available before the start of the course. All lectures will have full notes and a recording made available via Moodle.</td>
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</table>
Prerequisites / notice
There are no prerequisites to attend this course, however, students must be available to attend on all days of the course, including the oral presentation and colloquium. Attendance is compulsory.

Students will work in groups, and will assess one group per meal.

Performance will be assessed by means of:
1) Contribution to laboratory practical work (30.01.2023 - 8.02.2023);
2) A written test on course content (via Moodle, completed by 10.02.2023);
3) A 15 min oral presentation of laboratory results in a seminar with colloquium (active discussion) (17.02.2023);
4) A 5-page written report per group (deadline 24.02.2023).

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

752-6101-00L Dietary Etiologies of Chronic Disease

**Abstract**
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Objective**
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

**Content**
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Lecture notes**
There is no script. Powerpoint presentations will be made available on-line to students.

**Literature**
To be provided by the individual lecturers, at their discretion.

**Prerequisites / notice**
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

752-6403-00L Nutrition and Performance

**Abstract**
The course introduces basic concepts of the interaction between nutrition and exercise performance.

**Objective**
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

**Content**
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

**Lecture notes**
Lecture slides and required handouts will be available on the ETH website (moodle).

**Literature**
Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

**Prerequisites / notice**
No general knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

766-6304-00L Introduction to the Nutrition Research Process

**Abstract**
This course provides students interested in fundamental tools and concepts in human nutrition research, including topics such as study design, statistical analysis, scientific writing and communicating results. Preparation of a research proposal will consolidate student learning.

**Objective**
This course will familiarise students with the fundamental concepts, methodologies and terminology that apply to human nutrition research. The course features both didactic presentations and in-class practical exercises including topics such as study design, statistics, scientific writing and communicating results. Students will have the opportunity to consolidate their learning by preparing a research protocol to study a nutrition-related health problem, which will be submitted for grading and presented in an end-of-semester graded poster presentation.

On completion of this course, students will have improved:
- Understanding of experimental study design in basic and clinical research
- Familiarity with the research process and methods used in human nutrition
- Understanding of basic statistics and analytical skills used in preparing and reporting research, including in tables and graphs
- Ability to report scientific results in writing and orally
- Skills in scientific writing and an understanding of the publication process
- Proficiency in retrieval and interpretation of scientific literature

**Lecture notes**
The teaching slides used in the lectures will be made available weekly on Moodle before each class, as pdf files.

**Literature**
There is no recommended textbook or prior reading required for this class. Students will be provided with recommendations for further reading where relevant, with the lecture notes.

**Prerequisites / notice**
There are no prerequisites to attend this course, however, students must be available to attend on all days of the course, including the oral presentation and colloquium.

**Taught competencies**

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<td>Method-specific Competencies</td>
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<td>Project Management</td>
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<td>Critical Thinking</td>
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**Electives**

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<tr>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, C. Hartmann</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The course provides an overview about the following topics: Factors influencing consumer's food choice, food and health, attitudes towards new foods and food technologies, labeling and food policy issues</td>
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<tr>
<td>752-0801-00L</td>
<td>Food Law and Legislation</td>
<td>W</td>
<td>1</td>
<td>1V</td>
<td>K. Krell Zbinden, E. Zbinden Kaessner</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to the principles of the EU and international Organisations, Principles of the Swiss food law.</td>
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<tr>
<td>Course Code</td>
<td>Course Name</td>
<td>Credits</td>
<td>Tutor(s)</td>
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<tr>
<td>752-5100L</td>
<td>Functional Microorganisms in Foods</td>
<td>W 3</td>
<td>C. Lacroix, A. Geinaert, A. Greppi</td>
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<tr>
<td>752-5111L</td>
<td>Functional Microorganisms in Foods</td>
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<td>F. Constancias, G. Brogini, A. Greppi</td>
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<tr>
<td>551-0317L</td>
<td>Immunology I</td>
<td>W 3</td>
<td>M. Kopf, A. Oxenius</td>
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**Objective**

Knowledge of the principles and the structure of the EU in general and in the area of food safety, overview of the relevant bilateral agreements CH-EU as well as on the most important international organisations (Codex Alimentarius and WTO) and their influence on the Swiss regulations on food safety.

Knowledge of the structure of Swiss food legislation and the most important regulations of the Swiss food law. The general principles, institutions and execution of the Swiss food law as well as the implementation of food law in the context of self-supervision are known.

Analytical data and premises and their equipment can be judged in the legal context of food law.

**Content**

General introduction into the EU and in the area of food safety (regulation on food safety), legislative procedures in the EU, introduction into the relevant bilateral agreements CH-EU, introduction into international organisations (e.g. Codex Alimentarius), general principles of the Swiss food law and the most important regulations as well as the most important legal procedures, legal settlement and the duties and responsibilities of the Food control authorities.

**Lecture notes**

Copies of the presentations will be handed out.

**Literature**

Documents about Codex Alimetarius, the EU regulation as well as the Swiss food law and some regulations will be handed out.

**Prerequisites / notice**

Qualifications: General knowledge of the food sciences.
The lecture will be held in German.

**Abstract**

This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food processing and products and in the human gut. Documents about Codex Alimetarius, the EU regulation as well as the Swiss food law and some regulations will be handed out.

A list of topics for group projects will be supplied, with key references for each topic.

Copies of the presentations will be handed out.

**Objective**

To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- Protective Cures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.

- Legal and protection issues related to functional foods

- Industrial biotechnology of flavor and taste development

- Safety of food cultures and probiotics

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Copy of the power point slides from lectures will be provided.

A list of topics for group projects will be supplied, with key references for each topic.

Some contents will be provided by registered students who will present as a group an actual publication.

**Abstract**

This course will increase basic knowledge on biotechnological constructions and application of genetically modified organisms (GMO) which are used worldwide in food production systems. The course discusses health issues, the legislation frame and food safety aspects of GMO applications in agriculture, food production and consumption in Switzerland and EU-countries.

This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of GMO, especially on the molecular basis of GMO constructions with emphasis on genetically modified food in Switzerland and the EU. Criteria of rationale food safety and health assessment in agriculture and food consumption will be elaborated.

Overview on application in gene technology, the gene transfer potential of bacteria, plants and other organisms and the mostly used transgenes in food as well as on GMO used for food production and their detection technologies in food; food safety assessment of GMO food; information on the legislation in Switzerland and EU-countries

Copies of slides from lectures will be provided.

Actual publications from literature will be provided.

Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.

Some contents will be provided by registered students who will present as a group an actual publication.

**Abstract**

Introduction into structural and functional aspects of the immune system.

Basic knowledge of the mechanisms and the regulation of an immune response.

Basic knowledge of the mechanisms and the regulation of an immune response.

- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**Abstract**

Introduction into structural and functional aspects of the immune system.

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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td></td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### 752-6151-00L Public Health Concepts

**Abstract**

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

**Objective**

- To interpret the results of epidemiological studies
- To critically assess scientific literature
- To know the definition, dimensions and determinants of health
- To plan public health interventions and disease prevention projects
- To draw a bridge from evidence to policies and politics

**Content**

Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PK nutrition).

**Lecture notes**

Handouts are provided to students in the classroom.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### 376-0300-00L Translational Science for Health and Medicine

**Abstract**

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

**Objective**

After completing this course, students will be able to understand:

- Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)

**Content**

What is translational science and what is it not?

- Disease concepts and consequences for research
- Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources
- How to measure success?
- Outcome variables
- Improving the translational process

Challenges of communication?

- How independent is translational science?
- Academic boundary conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### 376-0225-00L Physical Activities and Health

**Abstract**

This course introduces/explores the complex relationship between physical activity, sedentary behavior and health. It will discuss the evolution of current physical activity recommendations and that identified physical activity as a key modifiable lifestyle behavior contributing to disease and mortality.

**Objective**

On completion of this course students will be able to demonstrate:

2. Thorough knowledge and critical awareness of current recommendations for physical activity, and current prevalence and trends of physical activity and associated diseases.
3. Awareness of current national and international physical activity policies and how they impact on global challenges.

**Content**

Introduction to Physical Activity for Health, including sedentary behavior

- Physical activity epidemiology; concepts principles and approaches
- Physical activity and all cause morbidity and mortality
- Physical activity and chronic disease; Coronary heart disease, diabetes, bone health, cancer and obesity
- Physical activity and brain health
- Physical activity and sedentary behavior recommendations
- Population prevalence of physical activity and sedentary behavior
- Physical activity policies
- Physical activity assessment
Literature

Core texts for this course are:

Prerequisites /notice

Selective journal articles from relevant journals such as Journal of Physical Activity and Health and Journal of Aging and Physical Activity

From the BSc-course the following book is recommended: ‘Essentials of strength training and conditioning’ T. Baechle, R. Earle (3rd Edition)

Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>766-6500-00L</td>
<td>MAS Master’s Thesis</td>
<td>O</td>
<td>20 credits</td>
<td>43D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only for MAS in Nutrition and Health.

Abstract

The study program is completed with the Master thesis, an independent scientific work. Topics are selected within the domains of the MAS program. The work is supervised by a lecturer of the MAS program.

Objective

The Master thesis must demonstrate the student's ability to independent, structured and scientific working.

Key for Type

O  Compulsory
W+ Eligible for credits and recommended
W  Eligible for credits

E- Recommended, not eligible for credits
Z  Courses outside the curriculum
Dr Suitable for doctorate

Key for Hours

V  lecture
G  lecture with exercise
U  exercise
S  seminar
K  colloquium

P  practical/laboratory course
A  independent project
D  diploma thesis
R  revision course / private study

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## MAS in Fire Safety Engineering

*Four-semester, part-time MAS programme, starting in autumn semester (even years).*

**Next start: Autumn Semester 2022**

### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>121-0100-00L</td>
<td>Module 1: Fire Science</td>
<td>O</td>
<td>10 credits</td>
<td>9G</td>
<td>A. Frangi</td>
</tr>
<tr>
<td></td>
<td><em>Only for MAS ETH in Fire Safety Engineering.</em></td>
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<tr>
<td>121-0110-00L</td>
<td>Module 2: Fire Safety Design</td>
<td>O</td>
<td>10 credits</td>
<td>9G</td>
<td>A. Frangi</td>
</tr>
<tr>
<td></td>
<td><em>Does not take place this semester.</em></td>
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<td><em>Only for MAS ETH in Fire Safety Engineering.</em></td>
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<tr>
<td>121-0140-00L</td>
<td>Module 5: Fire Protection Systems</td>
<td>O</td>
<td>6 credits</td>
<td>5G</td>
<td>A. Frangi</td>
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<td><em>Does not take place this semester.</em></td>
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<td><em>Only for MAS ETH in Fire Safety Engineering.</em></td>
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</tbody>
</table>

**MAS in Fire Safety Engineering - Key for Type**

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

**Key for Hours**

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |
| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Building Process Leadership

The MAS in "Gesamtprojektleitung Bau" is of a duration of 2 years, starting in autumn semester (n-service).

Start of the next course: Autumn Semester 2023

Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>067-0101-00L</td>
<td>Involved Parties</td>
<td>O</td>
<td>10 credits</td>
<td>21G</td>
<td>S. Menz</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester. Only for MAS in Building Process Leadership.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.</td>
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</tbody>
</table>
| Objective  | The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.  
- Expertise and personal skills  
- Organisational forms and SWOT analysis  
- Role, contracting and authority to issue directives  
- Responsibility  
- Leadership |
| Content    | Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'. |
| Lecture notes | Please find the teaching material, the further readings and information on our server. |
| Literature | www.map.arch.ethz.ch/en |
| Taught competencies | Subject-specific Competencies  
Concepts and Theories  
Techniques and Technologies  
Analytical Competencies  
Decision-making  
Media and Digital Technologies  
Problem-solving  
Project Management  
Communication  
Cooperation and Teamwork  
Customer Orientation  
Leadership and Responsibility  
Self-presentation and Social Influence  
Responsibility  
Diversity  
Negotiation |
| Method-specific Competencies | Concepts and Theories  
Techniques and Technologies  
Analytical Competencies  
Decision-making  
Media and Digital Technologies  
Problem-solving  
Project Management  
Communication  
Cooperation and Teamwork  
Customer Orientation  
Leadership and Responsibility  
Self-presentation and Social Influence  
Responsibility  
Diversity  
Negotiation |
| Social Competencies | Communication  
Cooperation and Teamwork  
Customer Orientation  
Leadership and Responsibility  
Self-presentation and Social Influence  
Responsibility  
Diversity  
Negotiation |
| Personal Competencies | Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  
Self-direction and Self-management |
| 067-0103-00L | Interests | O    | 10 credits | 11G   | A. Paulus, S. Menz |
|            | Only for MAS in Building Process Leadership. |
| Abstract   | In our third semester, we reconsider and re-evaluate our identity as a leading consultant. For this we see how the concept of leadership works on and shapes our skills. In line with our acquired knowledge we now pay attention to all involved interests: the perception of demand. Furthermore, it is a necessity to understand the tasks and duties of every role which you can take on. |
| Objective  | The students are able to understand the following terminologies, processes and competences. The are able to put them into practice.  
- Interests and positions, perception of demands  
- Concept of leadership  
- Construction industry and real estate market |
| Content    | In our third semester, we reconsider and re-evaluate our identity as a leading consultant. For this we see how the concept of leadership works on and shapes our skills. In line with our acquired knowledge we now pay attention to all involved interests: the perception of demand. Furthermore, it is a necessity to understand the tasks and duties of every role which you can take on. |
| Literature | www.map.arch.ethz.ch/en |

MAS in Building Process Leadership - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
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<tbody>
<tr>
<td>O</td>
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<td>W+</td>
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<td>W</td>
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<td>E-</td>
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<td>Z</td>
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<td>Dr</td>
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Key for Hours

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<th>Key for Hours</th>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in History and Theory of Architecture (GTA)

The MAS-programm in “History and Theory of Architecture” is a two-year half-time course and contains 60 CP. The course starts in the autumn semester.

Attendance of classes supplemented by independent research; practical training periods and excursions; lectures/seminars on one to two days per week, in total 600 ca. contact hours, in addition private study ca. 600 hours (for each in-class day one day of work preparation), two individually tutored seminar papers on chosen subjects (200 hours) and credited Master's thesis (600 hours).

1. Semester

Lectures, Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>056-0001-01L</td>
<td>Architecture and the City I</td>
<td>O</td>
<td>4</td>
<td>4S</td>
<td>S. Schindler Kilian, A. J. Bideau</td>
</tr>
</tbody>
</table>

Abstract: The seminar asks: What, exactly, constitutes a “historical moment”? How do so-called forks in the road, paradigm shifts, or turns manifest? We will explore this question with a particular focus on the interplay of architecture, city, and capital by closely looking at a series of historical constellations in the 19th and 20th centuries.

Objective: Through the interpretation of primary and secondary sources from the history of architecture and economics, and the juxtaposition with built works, students learn to understand the intersections between architecture, economics and politics and to articulate those relationships with precision and nuance. They learn to lead discussions and summarize key findings in written form.

Content: In order to identify the continuities and discontinuities between economics and architecture, the seminar is structured around turning points in economic history and related societal shifts. In this way, we will test new ways of conceptualising the relationships between architecture, money and the city in their local and global entanglements.

Prerequisites / notice: Will be posted on the MAS platform.

Workshop

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>056-0005-01L</td>
<td>Methods of Academic Writing I</td>
<td>O</td>
<td>1</td>
<td>3U</td>
<td>M.-A. Lerjen</td>
</tr>
</tbody>
</table>

Abstract: Through hands-on teaching, the methods workshops introduce students to the various approaches to academic writing in the humanities and convey the methodological foundations of architectural history. Lecturers and students discuss and work on research papers and master's theses as well as the group’s research project.

Objective: Students learn to identify and apply different methods of academic writing in architectural history. They acquire the ability to recognize and independently solve problems related to research and writing.

Essays

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>056-0201-01L</td>
<td>Scientific Home Work (1)</td>
<td>O</td>
<td>4</td>
<td>9S</td>
<td>S. Schindler Kilian, A. J. Bideau</td>
</tr>
</tbody>
</table>

Abstract: Students write a seminar paper on a subject of their choice in consultation with a lecturer, developing the skills to pursue independent academic work.

Objective: Students write an academic paper of approx. 3,000 words/20,000 characters.

2. Semester

Lectures, Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>056-0003-01L</td>
<td>Architecture and the City III</td>
<td>O</td>
<td>4</td>
<td>4S</td>
<td>S. Schindler Kilian, A. J. Bideau</td>
</tr>
</tbody>
</table>

Abstract: The seminar asks: What, exactly, constitutes a “historical moment”? How do so-called forks in the road, paradigm shifts, or turns manifest? We will explore this question with a particular focus on the interplay of architecture, city, and capital by closely looking at a series of historical constellations in the 19th and 20th centuries.

Objective: Through the interpretation of primary and secondary sources from the history of architecture and economics, and the juxtaposition with built works, students learn to understand the intersections between architecture, economics and politics and to articulate those relationships with precision and nuance. They learn to lead discussions and summarize key findings in written form.

Content: In order to identify the continuities and discontinuities between economics and architecture, the seminar is structured around turning points in economic history and related societal shifts. In this way, we will test new ways of conceptualising the relationships between architecture, money and the city in their local and global entanglements.

Prerequisites / notice: Will be posted on the MAS platform.

Workshop

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>056-0009-01L</td>
<td>Architecture and the City V</td>
<td>W</td>
<td>4</td>
<td>9S</td>
<td>S. Schindler Kilian</td>
</tr>
</tbody>
</table>

Abstract: "Architecture and the City V" serves as the container to register in the transcript the two electives at 2 credit points each which are required from MAS gta students for their degree. Students should register both for this course and for the electives.

Objective: The goal of requiring two electives is to expose MAS gta students to the range of content and methods being taught at gta/DARCH.

Workshop

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>056-0007-01L</td>
<td>Research Methods in the History and Theory of Architecture</td>
<td>O</td>
<td>1</td>
<td>3U</td>
<td>C. Rachele, S. Schindler Kilian</td>
</tr>
</tbody>
</table>

Abstract: Introduction to methodological approaches in the history and theory of architecture; presentation and discussion of individual projects.
Objective

The course in the first year of the doctoral program in the history and theory of architecture has a twofold objective: First, method sessions on central approaches in the history and theory of architecture provide a methodological basis for the doctorate at the Institute GTA. Secondly, in toolkit and review sessions, the doctoral students get support for their individual research projects and guidance for the production of the Research Plan they have to present at the end of the first year.

Content

The seminar course prepares the doctoral students for their Research Plan submission at the end of their first year. The weekly seminar will frame group discussions on a variety of topics, group presentations, and preparatory exercises. Students are encouraged to consider the course readings not only in terms of their content, but also as illustrations of formatting, structuring and argumentation methods, that can serve as research models.

There are four types of seminar classes. Toolkit classes focus on the individual components of the Research Plan: abstract, hypothesis, literature survey, research structure etc. Method classes cover research strategies and disciplinary traditions relevant for doctoral studies in the history and theory of architecture. Theory seminars focus on specific intellectual traditions and their comparison. The in-seminar Review sessions, leading up to the formal end-of-semester Doctoral Reviews with external guests, comprise work-in-progress presentations and peer-review appraisals.

The course schedule will be available at the beginning of HS 2021 on the course website: https://doctoral-program.gta.arch.ethz.ch/courses/research-methods-in-the-history-and-theory-of-architecture

Lecture notes

Scans of selected texts for discussion and exercises will be provided at the beginning of HS 2021 on the course website: https://doctoral-program.gta.arch.ethz.ch/courses/research-methods-in-the-history-and-theory-of-architecture

Literature

The following titles offer background and detailed information regarding research methodologies for a variety of disciplines.


Master's Thesis

Table: Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>056-0210-01L</td>
<td>MAS Thesis Preparation</td>
<td>O</td>
<td>5 credits</td>
<td>9A</td>
<td>S. Schindler Kilian, A. J. Bideau</td>
</tr>
</tbody>
</table>

Abstract

This one-semester module is dedicated to identifying the topic for the Master's thesis and developing the research plan. The Master's thesis itself is written in the following spring semester.

Objective

The aim is to develop a relevant hypothesis and research question for the Master's thesis that is based on an analysis of the current state of the field. Additionally, the research plan includes preparing an annotated bibliography, elaborating the methodological approach and a timeline of deliverables.

Content

The topic of the MAS master thesis is chosen by the students and further refined through individual consultation with the docents. At the end of the semester, the students present their research plan to external guest critics. The research plan comprises about 25,000 characters.

Literature

See internal MAS platform

MAS in History and Theory of Architecture (GTA) - Key for Type

| O       | Compulsory                          | E-   | Recommended, not eligible for credits |
| W+      | Eligible for credits and recommended | Z    | Courses outside the curriculum       |
| W       | Eligible for credits                | Dr   | Suitable for doctorate                |

Key for Hours

| V       | lecture                           | P    | practical/laboratory course         |
| G       | lecture with exercise            | A    | independent project                 |
| U       | exercise                          | D    | diploma thesis                      |
| S       | seminar                           | R    | revision course / private study     |
| K       | colloquium                        |      |                                      |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Introduction to the MAS Housing: Room HIT H 13 (Date and Time will follow in due time).

Presentation of MAS Thesis Proposals: Room HIT H 13 (Date and time will follow in due time).

**Core Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>057-0103-10L</td>
<td>Module 1: Global Housing Issues, Challenges and Strategies</td>
<td>O 4 credits</td>
<td>2G</td>
<td>J. E. Duyne Barenstein</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Globally over one billion people lack adequate housing. Meeting their housing needs requires innovative solutions that are affordable, inclusive, sustainable and scalable. We will critically review the causes and consequences of the current housing crisis and the various strategies through which a wide range of actors at local, national and international level are addressing the housing question.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The students will learn to understand the meaning of housing in relation to its broader socioeconomic, cultural, political, and spatial context and to critically reflect on the viability, effectiveness and sustainability of different housing strategies.</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>Housing is a human right but also one of the most daunting challenges of urbanisation globally. Currently over one billion people lack affordable and adequate housing, a number that may increase to 1.6 billion people within a decade. Ensuring access to adequate, safe and affordable housing to all is one of the targets of the 2030 Agenda for Sustainable Development. However, this target is unlikely to be met without a radical change in housing policies and practices. Indeed, meeting millions of people’s housing needs requires innovative solutions that are inclusive, sustainable and scalable. The course focuses on the causes and consequences of the global housing crisis. Further it will critically reflect upon the concept of adequate housing and on the various strategies through which national governments, municipalities, the private sector, and communities in different contexts have been, or are currently addressing the housing question.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>A reader will be distributed at the beginning of the semester containing an overview of all lectures, the involved exercises, and required readings.</td>
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</table>

| 057-0104-10L | Module 2: Innovative Housing: Case Studies and Exercises | O 4 credits | 2G | J. E. Duyne Barenstein |
| **Abstract** | With the aim of understanding the role of architecture in responding to the constantly changing housing needs and demands we will visit and analyze a selected number of housing projects that are innovative from a social, institutional and architectural perspective. |
| **Objective** | The students will gain a better understanding of the socioeconomic, cultural and institutional factors determining innovation in the housing sector. |
| **Content** | All over the world a wide range of public and private organizations are responding to the qualitative and/or quantitative housing deficits through innovative projects. With the aim of understanding the role of architecture in responding to the constantly changing societal needs and aspirations we will visit and analyze a selected number of groundbreaking housing projects. Interactions with relevant stakeholders will enable students to reflect upon their innovative character from a social, institutional and architectural perspective. These visits will be followed by individual and group exercises; based on a common analytical framework the students will identify through secondary sources additional paradigm-shifting housing projects in different parts of the world with the aim of gaining a better understanding of the links between housing initiatives and their societal context. |
| **Lecture notes** | A reader will be distributed at the beginning of the semester containing an overview of all lectures, the involved exercises, and required readings. |

| 057-0101-10L | Module 3: Housing Research Methods | O 10 credits | 2G | J. E. Duyne Barenstein |
| **Abstract** | This course offers an introduction to a wide range of research methods currently used in housing and neighbourhood studies. Students will be invited to reflect on the value of using different tools to inform evidence-based design processes and to provide rigorous answers to research question by covering all the steps of the research cycle. |
| **Objective** | Students will acquire the theoretical and methodological skills to design and carry out an independent scientific research project. |
| **Content** | This course offers an introduction to a wide range of research methods currently used in housing and neighborhood studies. Students will be invited to reflect on the value of using different tools to inform evidence-based design processes and to provide rigorous answers to research questions by covering all steps of the research cycle. Particular emphasis will be given to qualitative and participatory research methods that will enable the students to directly engage with stakeholders, such as residents, representatives of housing and neighborhood associations, and public authorities. By combining theory and practice, they will learn to apply them to a specific context and research question. Through lectures with practical group exercises the course will equip students with the required knowledge and skills to develop an individual research project that will lead to their MAS theses. |
| **Lecture notes** | A reader will be distributed at the beginning of the semester containing an overview of all lectures, the involved exercises, and required readings. |
| **Prerequisites / notice** | Course only open to students enrolled in the ETH MAS in Housing. |

| 057-0102-10L | Module 4: Writing and Communication Skills for Built Environment Professionals | O 10 credits | 2K | J. E. Duyne Barenstein |
| **Abstract** | The course is intended to support the students to develop their individual research proposals and to attain the necessary skills to work independently and with scientific rigour on a project leading to their final MAS thesis. |
| **Objective** | In the framework of Module 4, students will learn the fundamentals of conducting their own research project, from defining a clear research question, to formulating valid hypotheses, and developing a feasible research design. The course is intended to support the students to develop their individual proposals and to attain the necessary skill to work independently and with scientific rigour on a project leading to their final MAS thesis. |
| **Content** | A core element of the MAS ETH in Housing is the elaboration of a research-based individual thesis. This module offers 10 ECTS credit points. In the framework of Module 4, students will learn the fundamentals of conducting their own research project, from defining a clear research question, to formulating valid hypotheses, and developing a feasible research design. The course is intended to support the students to develop their individual proposals and to possess the necessary skill to work independently and with scientific rigour on a project leading to their final MAS thesis. |
| **Lecture notes** | A reader will be distributed at the beginning of the semester containing an overview of all lectures, the involved exercises, and required readings. |
Elective Courses

At least 3 elective courses for a total of 6 ECTS have to be followed by the MAS students. These can be selected from the courses offered by the Department of Architecture or from other ETH departments.

### MAS in Housing - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

### Key for Hours

<table>
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<th>Description</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
1. Semester

Core Courses

General Management and Human Resource Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0341-00L</td>
<td>Introduction to Management</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>Z. Zagorac-Uremovic, D. Baschung, J. O'Neil</td>
</tr>
</tbody>
</table>

Abstract
This course is an introduction to the critical management skills involved in planning, organizing, leading and controlling an organization.

Objective
By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate routine operations in order to meet evolving customers’ and societal needs. The students will achieve these goals by being able to:
- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how change, internally or externally initiated, impact such relationships

Content
This course is an introduction to critical management skills involved in planning, organizing, leading and controlling an organization. This course follows a 'systemic' view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations: Input (i.e., from external environment), strategy, people, work, formal and informal structure of the organization, and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements together by means of real-life cases, whereby the focus will be on the critical reflection of particular cases of fits and misfits between those elements and on the application of a selection of tools and methods.

Lecture notes
The content of the course will rely on different readings, cases and selected chapters of following book:

Literature
The content of the course will rely on different readings and on selected chapters of following book:

Prerequisites / notice
Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on moodle. This preparation is required to participate in the lectures.

The final exam is requested for all types of students (BSc, MSc, MAs, PhD, and Exchange students). It is not possible to retake the exam within the same term or academic year.

Taught competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Method-specific Competencies
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility

Social Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Personal Competencies
- assessed
- not assessed
- not assessed
- not assessed

Work Design and Organizational Change

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0301-00L</td>
<td>Work Design and Organizational Change</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>G. Grote</td>
</tr>
</tbody>
</table>

Abstract
Good work design is crucial for individual and company effectiveness and a core element to be considered in organizational change. Meaning of work, organization-technology interaction, and uncertainty management are discussed with respect to work design and sustainable organizational change. As course project, students learn and apply a method for analyzing and designing work in business settings.

Objective
- Know effects of work design on competence, motivation, and well-being
- Understand links between design of individual jobs and work processes
- Know basic processes involved in systematic organizational change
- Understand the interaction between organization and technology and its impact on organizational change
- Understand relevance of work design for company performance and strategy
- Know and apply methods for analyzing and designing work
The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterion
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

A list of required readings will be provided at the beginning of the course.

The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.

### Strategy, Markets and Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0403-00L</td>
<td>Introduction to Marketing</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Brüggemann</td>
</tr>
</tbody>
</table>

#### Objective
After taking the class, students will be able to

1) Define what marketing is and describe its role at different stages of the value chain
2) Apply psychological theories to analyze behavior (e.g., purchase behavior) and identify the needs of (prospective) customers in consumer and business markets
3) Design elements of the marketing mix—e.g., develop new products and set prices—in a way that creates long-term value
4) Create an effective and efficient marketing mix that attracts and engages customers, e.g., by running targeted promotions
5) Use quantitative methods and customer data to manage relationships with customers

#### Content
The structure of the course will roughly follow the different steps of the value chain, i.e., the set of activities necessary for offering valuable products to customers. First, it will introduce students to psychological theories that help explain behavior, e.g., purchase behavior. It will also familiarize students with different methods from marketing research, which can be used to identify the needs of customers. Next, the course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing. A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

The course is designed to be “hands-on”, with opportunities to apply skills on business cases involving real-world marketing data. It will feature guest lectures from industry experts. The class might be taught in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned reading material for self-study.

#### Literature
The lecture covers a wide range of theory-based thinking tools and practical management methods. These include business model innovation and digital business models, key performance indicators in the digital space, subscription business models, the logic and characteristics of platform business models, organizational change and hybrid organizations, lessons from transaction cost theory, network theory and technology management.

All lecture content is provided via the Moodle platform.

This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:
1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0541-00L</td>
<td>Systems Dynamics and Complexity</td>
<td>W+</td>
<td>3 credits</td>
<td>3G</td>
<td>F. Schweitzer</td>
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</table>

Quantitative and Qualitative Methods for Solving Complex Problems

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1439 of 2345

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini). Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

### Micro and Macroeconomics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>J.-E. Sturm</td>
</tr>
</tbody>
</table>

**Abstract**

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective**

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

**Content**

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policymakers.

**Lecture notes**

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

**Literature**

The course is structured along three main tasks:

1. Finding solutions
2. Implementing solutions
3. Controlling solutions

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts.

These are provided as home work and two of these will be graded (see "Prerequisites").
Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td></td>
<td>Leadership and Responsibility</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
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</table>

363-0503-00L Principles of Microeconomics

W+ 3 credits 2G M. Filippini

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a fair distribution.

Objective
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

Content
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a fair distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
The book can also be used for the course 'Principles of Microeconomics' (Sturm)
For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
By attending this course, students will be able to:

A. Concepts and Theories

This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at improving and establishing position of firms within an industry.

The first part of the course is devoted to financial accounting. It teaches the principles of double-entre accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

Prerequisites / notice

This course is a prerequisite for the course Financial Management.

Autumn Semester 2022

Core Courses

Strategy, Markets and Technology

In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share their insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

This course is a prerequisite for the course Financial Management.

TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Presentation slides will be made available on moodle prior to lectures.

Prerequisites / notice

Number of participants limited to 80.

The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Presentation slides will be made available on moodle prior to lectures.

Prerequisites / notice

Number of participants limited to 80.

This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at improving and establishing position of firms within an industry.
Objective
The lecture "Strategic Management" is designed to teach relevant competences in strategic planning and -implementation, for both professional work-life and further scientific development. The course provides an overview of the basics of strategy and the most prevalent concepts and methods in strategic management. The course is given as a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the case companies. In two sessions, the students will also be addressing real-time strategic issues of firms that are represented by executives.

Content
Contents:
27.09.2021: Guest Lecture (Dr. Berg) and Introduction
04.10.2021: Strategy concepts
18.10.2021: Industry dynamics I: Industry analysis + Case Studies
25.10.2021: Guest Lecture (Patrick Warnking, Google) + Case Studies
01.11.2021: Industry dynamics II: Analysis of technology and innovation + Cases
15.11.2021: The resource-based theory of the firm + Cases
22.11.2021: The knowledge-based theory of the firm + Cases
29.11.2021: Guest Lecture (Andy Staubli, PwC) and course summary

Strategic Management offers a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the involved companies. This aims at offering students a sound and theoretical understanding of important and current topics and also offer an opportunity to present these concepts in front of an audience.

This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at analyzing and establishing position of firms within an industry, securing firm performance. Thus, the course focuses on a number of important topics, such as the evolution of industry, industry structure, the analysis of a firm's resources- and knowledge, and innovation. In addition, student groups will hold presentations on the four main topics of this class, to further develop concepts and enhance understanding. The presentations will cover Industry Dynamics I, Industry Dynamics II, Resource Based View of the Firm, Knowledge Based View of the Firm. For all presentations, selected Harvard Business Cases will be used as a common ground for students to start from.

Students are also expected to read and understand the required readings (approx. 15 items) that cover the most important papers and articles from the past 30 years in management and strategy research.

To underline the relevance of Strategic Management in firms, decision makers from companies in Switzerland will be holding guest lectures about their take on strategy in practice and give insight on current topics in the field.

Prerequisites /
Number of participants limited to 80. Registration through myStudies (first come, first served). We do not use the mystudies-Waiting List, but a separate internal system. A lot of people deregister at the start of the semester so stay in the waiting list at any point!

For further questions and if you are unable to sign up through myStudies, please contact the course assistant: http://www.smi.ethz.ch/education/practicing-strategy.html

For participants of the MAS-MTEC program we offer a complimentary course Practicing Strategy in which students will apply the concepts of Strategic Management to their real-life contexts and organizations. Please register simultaneously for both courses if you want to take part in this course.

For more information please see: http://www.smi.ethz.ch/education/practicing-strategy.html

Information and Operations Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0453-00L</td>
<td>Strategic Supply Chain Management</td>
<td>Wa+</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Wagner</td>
</tr>
</tbody>
</table>

Abstract
The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms competitive strategies and marketing priorities.

Objective
After completing this course:
1. Students can explain the importance of supply chain management for a firm's strategy and success
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings
4. Students can describe and evaluate fundamental logistics and supply chain concepts
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
6. Students are familiar with current developments and trends in supply chain practices

Content
Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains ought to be aligned with and support the achievement of the firm's corporate, business and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains.

Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain's role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

Lecture notes
The course material will be made available for download on Moodle:
https://moodle-app2.let.ethz.ch/course/view.php?id=17834

All organizational matters will be handled by the teaching assistant Christian Wagner (cwagner@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

Literature
The following textbook is recommended:

The following textbook is supplementary:
The goal of the lecture is to understand the main challenges of corporate transformation and to demonstrate the application of a holistic project procedure model for corporate transformation projects with special emphasis on the alignment of business and IT.

The student should understand and be able to explain the main reasons for corporate transformation, the relevant management processes to manage corporate transformation, the interdependencies between strategy, processes and information systems, especially how this three levels interrelate, the critical success factors for the successful accomplishment of large scale corporate transformation projects, the main instruments of project, quality and change management and the different types of resulting IT projects.

Content
The globalization of the world leads to an increasingly faster pace in business transformation. Enterprises have to adapt faster and even faster to the environmental changes in a global economy to remain competitive and to make sure they stay in business. In todays information age this does not only mean to adapt business strategy and business processes but also to adapt information systems to the new circumstances. The fast adaptation through large scale corporate transformation projects that change strategy, business processes and information systems is critical to ensure competitiveness for tomorrow. The introduction of new business processes and information systems typically takes years in very complex large scale projects. Many projects fail because of insufficient alignment between decision makers in business and IT. Unclear understanding of the overall project scope, undefined roles and responsibilities, unclear project processes, quality problems and resistance to change are some typical problems found in such projects. The lecture is subdivided into following modules:

- Corporate development introduction and motivation
- Parallelization of corporate development and complexity reduction
- Planning process and project portfolio management in corporate development
- Management of large scale projects integration of strategy, processes and information systems
- Quality management in large scale projects
- Project management in large scale projects
- Change management within projects. The lecture is accompanied by four case studies that are used to exemplify the contents of the lecture by applying the concepts to real situations in corporate life.

Quantitative and Qualitative Methods for Solving Complex Problems

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0305-00L</td>
<td>Empirical Methods in Management</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Tillmanns</td>
</tr>
</tbody>
</table>
| Abstract   | In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on eviden-
|            | based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created
|            | videos.                                   |      |      |                   |
| Objective  | The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing
|            | the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical
|            | approaches.                               |      |      |                   |
| Content    | Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understand of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics. The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to that, there will be some non-mandatory online exercises as an additional opportunity to prepare for the exam. |

Literature
Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.

Prerequisites / notice
The course includes out-of-class assignments and projects to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups. Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.

363-1004-00L Operations Research

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
| Abstract   | This course provides an introduction to operations research methods in the fields of management science and economics. Requisite
|            | mathematical concepts are introduced with a practical, problem-solving perspective. |
| Objective  | - Introduction to building and using quantitative models in a business / industrial environment
|            | - Introduction to basic optimization techniques (Linear Programming and extensions, network flows, integer programming, dynamic and
|            | stochastic optimization) |
|            | - Understanding the integration of quantitative models into the managerial decision process |      |      |                   |

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1444 of 2345
The economic environment of today’s companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative models and methods of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analyzed and optimized using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:

- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

Lecture notes
Any standard textbook in Operations Research is a useful complement to the course.

Literature
Any printed script will be made available.

Prerequisites / notice
Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.

### Micro and Macroeconomics

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0537-00L</td>
<td>Resource and Environmental Economics</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>L. Bretschger</td>
</tr>
</tbody>
</table>

**Abstract**

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

**Objective**

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

**Content**

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and markets; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

**Literature**


### Financial Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0723-00L</td>
<td>Corporate Finance</td>
<td>W+</td>
<td>3 credits</td>
<td>A. Kind</td>
</tr>
</tbody>
</table>

**Abstract**

"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

**Objective**

Upon successful conclusion of the course, students will ...

1) know what corporate finance and corporate governance are about;
2) be able to price a wide array of corporate securities, assets, and projects, e.g., stocks, bonds, and options;
3) master three valuation approaches (discounted cash-flow valuation, relative valuation, and real-options valuation) and know about their applicability, their strengths, and their weaknesses;
4) know how to finance firms at different stages of their lifecycle;
5) know terms, acronyms, and concepts in the world of finance;
6) know how to relate real-world corporate events (past and current) to concepts learnt in class;
7) have increased their appeal as future manager, employee or entrepreneur by relevant knowledge in the field of finance in general and corporate finance in particular.
"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

In the following, for each of the three parts of the course, key aspects, are listed.

Part I: Corporate Finance and Corporate Governance
- Corporations and their characteristics (e.g., centralized management, limited liability, free transferability of economic claims, legal personality)
- Corporate finance and its goals (e.g., shareholder-value approach vs. stakeholder-value approach)
- Corporate governance problems and possible solutions (e.g., over-investment, under-investment, self-dealing, monetary incentives, board of directors, the market of corporate control, leverage, product-market competition)

Part II: Investment Decisions/Valuation
- Discounting and compounding
- Present value tools (e.g., perpetuities, growing perpetuities, annuities, growing annuities)
- Bond pricing and interest rates (e.g., types of bonds, term structure of interest rates, yield-to-maturity, duration concepts, forward rates, "riding the yield curve")
- Risk and return (e.g., moments of stock returns, modern portfolio theory, capital market line, systematic risk vs. unsystematic risk)
- CAPM in practice (e.g., computation of the risk free interest rate, beta, and the market risk premium; security market line)
- DCF Analysis: Cost of capital and cash flow estimation
- Relative valuation (e.g., earnings multiples, book multiples, sales multiples, fundamental drivers of multiples)
- Real options (e.g., option to abandon, option to delay, option to expand)

Part III: Financial Policy
- Corporate financing (e.g., instruments, internal vs. external financing, equity financing vs. debt financing, crowdfunding, M&M and beyond)
- Payout policy (e.g., dividends, par value reductions, share buybacks, M&M and beyond)

Lecture notes
Slides in English (and any other relevant material) will be available for download on the following website: https://moodle-app2.let.ethz.ch/course/view.php?id=4479

Literature
For the exam, only the material provided will be relevant.
However, interested students may refer to the following textbook for an alternative, or a complementary, reading:


363-0561-00L Financial Market Risks W+ 3 credits 2G not available

Does not take place this semester.

Abstract
I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

Objective
The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

- Development of the concepts and tools to understand these risks and master them.
- Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)
- Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks
### Content

1. The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of the perpetual money machine.

2. Risks in financial markets
   - What is risk?
   - Measuring risks of financial assets
   - Introduction to three different concepts of probability
   - History of financial markets, diversification, market risks

3. Introduction to financial risks and its management.
   - Relationship between risk and return
   - Portfolio theory: the concept of diversification and optimal allocation
   - How to price assets: the Capital Asset Pricing Model
   - How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4. Financial markets: role and efficiency
   - What is an efficient market?
   - Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
   - Deviations from efficiency, puzzles and anomalies in the financial markets
   - Financial bubbles, crashes, systemic instabilities

5. An introduction to Options and derivatives
   - Calls, Puts and Shares and other derivatives
   - Financial alchemy with options (options are building blocks of any possible cash flow)
   - Determination of option value; concept of risk hedging

6. Valuation and using options
   - A first simple option valuation model
   - The Binomial method for valuing options
   - The Black-scholes model and formula
   - Practical examples and implementation
   - Realized prices deviate from these theories: volatility smile and real option trading
   - How to imperfectly hedge with real markets?

7. Real options
   - The value of follow-on investment opportunities
   - The timing option
   - The abandonment option
   - Flexible production
   - Conceptual aspects and extensions

8. Government bonds and their valuation
   - Relationship between bonds and interest rates
   - Real and nominal rates of interest
   - Term structure and Yields to maturity
   - Explaining the term structure
   - Different models of the term structure

9. Managing international risks
   - The foreign exchange market
   - Relations between exchange rates and interest rates, inflation, and other economic variables
   - Hedging currency risks
   - Currency speculation
   - Exchange risk and international investment decisions

### Lecture notes
Lecture slides will be available on the site of the lecture

### Literature
- Corporate finance
- Brealey / Myers / Allen
- Eight edition

### Prerequisites / notice
- none

### Skill-Based Training, 1. and 3. Semester

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>365-1099-00L</td>
<td>Design Thinking: A Human-Centred Approach to Problem Solving</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>A. Cabello Llamas</td>
</tr>
</tbody>
</table>

* Exclusively for MAS MTEC students (3rd semester).

* Minimum number of participants: 15 students.

**Abstract**

In this course, students get to know Design Thinking, which is an innovation method that can be applied to solve a broad range of problems from product development to social innovation. The students will engage in collaborative team exercise to learn about and directly apply the five typical design thinking steps – empathize, define, ideate, prototype and test – by solving a real-world challenge.

**Objective**

During the course, students will:

- get to know the design thinking process working on a specific real-world challenge
- learn when to apply design thinking methodology
- learn how to empathize with users, how to formulate a clear problem statement, develop ideas, prototype as well as test them with potential users
When talking of leadership, one in most cases refers to the interaction between superior and associate. However, leadership in modern times also involves the interaction with peers, with one's own superior as well as with other stakeholders. Thus, not leadership but personal skills are needed which also comprise communication, self-management and personality aspects.

During the course, students will... - get to know the design thinking process as:
- a methodology to develop ideas and concepts – typically in the early phase of the innovation process (the fuzzy-front end)
- a methodology used for product, service and business model innovation
- a methodology used for organizational development: process improvements, redesign of organizational structures, etc.
- learn how to apply the design thinking methodology or parts of it
- learn how to empathize with users: simple interview techniques, observation, etc.
- learn how to formulate a clear problem statement
- learn how to develop ideas: potentially alternative brainstorming techniques
- learn how to prototype ideas with simple means
- learn how to test them with potential users: simple test structures

What the students should learn from the course:
- Students will be able to assess whether Design Thinking is useful methodology to solve challenges they face in their daily business activities.
- Students will be able to use elements (i.e. a novel brainstorming technique, a novel feedback method, etc.) in their daily business activities.

What the students will NOT learn:
- This 2-day training is by not extensive enough to provide a full-scale design thinking training that enables students to design, organize and run their own design thinking workshops and projects. For this, further courses, trainings and self-guided learning is necessary.

References to institutes, books and other material will be provided.

<table>
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<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Semester</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>365-1019-00L</td>
<td>Human Resource Management: Skills in Practice</td>
<td>2</td>
<td>2S</td>
<td>M. Gubler, M. Kolbe</td>
</tr>
<tr>
<td>365-1092-00L</td>
<td>Personal Leadership Skills</td>
<td>2</td>
<td>3S</td>
<td>P. Romann</td>
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<tr>
<td>365-0347-00L</td>
<td>Negotiation Skills</td>
<td>1</td>
<td>1S</td>
<td>M. Gutmann</td>
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</tbody>
</table>

Abstract

Content

Objective

Literature

Prerequisites

Exclusively for MAS MTEC students (3rd semester).

Prior participation in the lecture 'Human Resource Management: Leading Teams' (363-0302-00) in spring semester is recommended.

Based on several core Human Resource Management processes, this seminar teaches practical skills in HRM and leadership in teams. Using a variety of interactive methods and discussions of real-life situations, it provides a highly practice-oriented approach to dealing with potential HRM- and team-related conflicts at work.

Participants are able to cope with potentially difficult HRM-related situations they may encounter as line managers and team leaders.

Based on four Human Resource Management core processes (recruiting, performance management, compensation, and training and development), this seminar focuses on practical skills in HRM and leadership in teams from a managerial point of view. Using a variety of interactive methods (e.g. role plays) and discussions of real-life situations, it provides a highly practice-oriented, yet theoretically grounded approach to dealing with potential HRM- and team-related conflicts at work.

Topics covered in the seminar include (but are not limited to) questions around hiring new staff, employee motivation (or a lack thereof), measuring performance, fair and effective compensation, pros and cons of monetary incentives, opportunities and limitations of career development in organizations. Furthermore, participants will learn and practically apply techniques that help them to deal with team-related conflicts. Thereby, they gain a better understanding of how and why conflicts in teams may arise and how they can be solved.

The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader.

The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader.

In the light of this, this seminar offers you the opportunity to acquire competencies in all of the just mentioned subjects and to reflect on your current behaviour as (future) leader. The more familiar we are with ourselves, the more we become aware of our needs, the freer we are to express ourselves and to interact with others.

The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader.

Be familiar with and feel able to able current concepts and theories related to leadership skills based on practical examples, own experiences and team discussions complemented by short theory sessions.

1 Fundamentals of Communication
2 Communication in Business Life
3 Self-Management
4 Personality and Understanding Human Nature
5 Fundamentals of Leadership
6 Leadership Tools

365-0347-00L Negotiation Skills

- Students, who have already successfully completed the course "Negotiation and Advocacy Skills" can't register again.

Participants are introduced to practical frameworks for negotiations apply them in negotiation simulations, discussions and exercises.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1448 of 2345
The Personal Branding and Storytelling course will be divided into the following sessions:

<table>
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<td></td>
<td>This two-day skills course gives students a basic introduction to how individuals and organizations represent their interests and create value in negotiations, which are often defined as exchanges between parties designed to reconcile their differences and produce a settlement. The course comprises a mixture of lectures, discussions, group work and simulations. Students do not need any experience or knowledge of negotiations, though those that do are invited to share their experience in discussions.</td>
</tr>
</tbody>
</table>

In this course participants are introduced to the practical dimensions of how individuals and organizations represent their interests in negotiations. Participants will learn basic frameworks and theories for

- negotiation context analysis
- preparing to negotiate
- best-practices for effectively negotiating

and apply them to practical contexts through discussions, group exercises and simulations.

The first day focuses on:

- Planning and preparation for negotiations
- Analyzing and understanding different types of negotiation contexts
- Common frameworks for negotiations
- 2 party negotiation simulation

The second day focuses on:

- Social dimensions (power, influence, persuasion, behavior cues, culture, and gender) of negotiations
- Ethics and ethical dilemmas in negotiations
- 5 party negotiation simulation

The course is structured to give an introductory overview of the topics. Recommended readings for further studies will be provided on moodle. Students will be required to read the instructions for the negotiation simulation before arriving in class. Attendance and participation is required on both course days.

The Personal Branding and Storytelling course will be divided into the following sessions:

<table>
<thead>
<tr>
<th>365-1149-00L Introduction to Personal Branding and Storytelling</th>
<th>W</th>
<th>1 credit</th>
<th>1S</th>
<th>B. Rübel, P. Geissbühler</th>
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<tr>
<td>Exclusively for MAS MTEC students (1st and 3rd semester).</td>
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<td>Please register by 31.08.2022 at the latest via myStudies.</td>
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<td>Minimum number of participants: 15 students.</td>
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We will have a "personal brand" - whenever you are interacting others, you are projecting an image of yourself. Are you ready to take charge of your own brand story and proactively guide your image? Would you like to learn how to effectively tell your story in a memorable way? This course will teach you skills you can rely on throughout your career to help you achieve your goals.

Specific take-aways from this course:

- Your current personal brand
- Your desired personal "brand house"
- Storytelling frameworks
- Building of your personal story and practice giving it
- Review of online & offline communication channels with an action plan to activate
- Revision of your LinkedIn profile to reflect your personal brand
- Your Personal Journal to keep and reflect on throughout your career as well as the toolkit you need to refresh your brand house as needed

Content

The Personal Branding and Storytelling course will be divided into the following sessions:

| Pre-work: you will be expected to distribute a survey to 5-6 members of your trusted network (e.g. friends, family and work colleagues). The surveys are private and only you will see the information. The survey will be the basis of defining your current personal brand. Additional pre-work will be reading through some articles and completing the first section of your Personal Journal. |
| Brand Basics: gain a common understanding of what a brand really is and why it is important. We will explore the difference between a corporate brand and a personal brand. |
| Brand Building: using the pre-work material, we will look at your current personal brand vs. your desired brand. We will take an in-depth look at all parts of a brand house and help you define your own Unique Selling Points (USPs). We will have exercises and break into small teams as needed. |
| Storytelling Basics: gain a common understanding of the importance of storytelling and different frameworks to approach it. |
| Storytelling Practice: you will spend time developing your personal story. We will have exercises and break into small teams as needed. You will be given the opportunity to tell your story and obtain feedback. |
| Communication Channels: we will review the various online and offline communications channels open to you to build your brand with a strong focus on LinkedIn. You will develop a personal action plan based on the channels most relevant to your industry and profession. |

Attendance at both days of the course, active participation in the exercises and finishing the post-class assignment is mandatory for successful completion of the course. Students will be expected to fully complete the pre-work required, including gathering the Trusted Network Survey data and filling in the first part of the Personal Journal. Literature and readings will be announced beforehand.

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<th>Taught competencies</th>
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<td>Social Competencies</td>
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<td>Self-presentation and Social Influence</td>
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<td>Personal Competencies</td>
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<td>Self-awareness and Self-reflection</td>
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<th>Electives, 1. and 3. Semester</th>
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<td>365-1145-00L</td>
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<tr>
<td>Exclusively for MAS MTEC students (3rd semester).</td>
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The focus is on how financial and investment theory is applied to real world problems. We compete in the economy, but are also exposed to financial markets. The specific point of view, the language of financial markets are discussed using illustrative case studies. Managers will learn how their company is rated for debt financing; and how its value reflects in the “mirror” of private equity funds.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1449 of 2345
The course aims to support managers in:

1) Understanding the mechanisms, language, and drivers of the debt and equities markets
2) Apply this understanding to specific corporate situations, such as optimizing the cost of capital (debt and equity) of the firm or projects
3) Use these insights to learn to think and act as an investor e.g. for the firm’s own pension fund

The general objective of the course is to enable MAS students with post work experience to think critically about concepts discussed in class during the course on Introduction to Management (i.e., the transformation process by Nadler and Tushman, 1980) and their own professional challenges.

Key actors in the financial markets. How central banks, commercial banks, and institutional investor influence market trends.

The business cycles: How and why economies rhyme into and out of growth? The mechanism of boom and bust and recessions.

The debt capital market. How companies can benefit from an understanding of the debt market? The importance of financing choices as a competitive advantage.

The equities capital market. How and why equities are issued? How investors categorize the equities markets?

The derivatives market. The origins and importance of derivative markets. The specific characteristics that make them both very useful and extremely hazardous.

The currency markets. Mechanisms of currency hedging in the International markets. The importance of a sound currency strategy to avoid large losses.

Private equity and venture capital. The actors in private debt and equities. The rise of start-ups within a new financial infrastructure.

Hedge Funds. An important new actor in the financial markets.

Initial public offering. How IPOs are organized and executed. The intricacies of the pricing process. When and how are participants disappointed. IPOs as an indicator for the overall market sentiment.

The bloc-course is about change leadership. It provides MAS students with coaching and mentoring from two senior change leaders in the attempt to develop critical management skills and bridge the gap between theory and practice.

The general objective of the course is to enable MAS students with post work experience to think critically about concepts discussed in class during the course on Introduction to Management (i.e., the transformation process by Nadler and Tushman, 1980) and their own professional challenges.
### Content

In today’s VUCA world that is Volatile, Uncertain, Complex and Ambiguous, how will you lead disruptive change due to Innovation and Technology evolution instead of being swept away by it? Have you mastered the process of leading change? Do you have a specific plan of action for the most critical problem you are trying to solve right now? If not, this is the course for you. You will learn lessons from relevant, current case studies that will bring out specific learnings in each of the 4 modules of the class – Innovation, Change Management, Leadership and Application.

The first module explores how a practical and effective Innovator as an Intrapreneur Leading an established Technology Driven Enterprise, or as an Entrepreneur. Starting with clear definitions of the ‘problem’ and the ‘customer’, you will work through the steps of clarifying the value proposition of the innovative process or product, testing, pivoting and fast iterations, and moving with confidence to implementation.

With Technology and Innovation being necessary but insufficient starting points, the next two modules will dig deep into successful Change Management and Leadership at all levels to ensure aligned and effective execution. The case studies will highlight both successes, and failures, of prior experiences.

This class is taught ‘by practitioners for practitioners’ with the final module focused on a customized Framework of Application introduced during prior modules. You will bring your priority challenge to the class, and through small group work and individual coaching, you will develop a plan of action. A final ‘elevator speech’ will give immediate feedback with which you can enhance the plan and apply it immediately back in your organization.

Separately, the D-MTEC MAS Mentoring Programme is available, should you desire continuing help to support your planning and execution after the course, or more generalized career development ideas.

### Literature

Literature and readings will be announced beforehand.

### 365-1166-00L Lean Production

**Objective**

After taking this course, students will be able to:

1. Operationalize and apply the just-in-time principle in manufacturing
2. Design a production system that minimizes quality errors
3. Work in a team to solve problems with selected problem-solving tools
4. Understand the role of behaviours and leadership in lean transformations
5. Select and apply new Industry 4.0 technologies to support the lean transformation

**Abstract**

This course (i) introduces the fundamentals of Lean Production and (ii) shows how new Industry 4.0 technologies can support a lean transformation. Through lectures, hands-on serious games, reflection and discussions, students learn (i) how lean production differs from other forms of production and (ii) how lean in synergy with new technologies can increase productivity in a production setting.

**Content**

This course is organized as a block course with two full lecture days. Day 1 focuses on the fundamental lean production principles and practices. Students get intimately familiar with lean production through a hands-on and immersive serious game and integrated reflection rounds. Day 2 focuses on how new technologies challenge and enhance the classic lean principles through presentations, hands-on exercises, and discussions. After each day, students write reflection notes with peer-review. The course is useful both for students with no previous experience of lean as well as for students with extensive experience of lean.

### 365-1059-00L Practicing Strategy

**Objective**

The course has two goals. First, participants learn to decompose complex real life problems into underlying strategic issues. Second, students learn to transfer and use the concepts and methods from the Strategic Management course to develop suitable solutions.

**Abstract**

This lecture is a special course for MAS students which supplements the Strategic Management course. Participants work on real-life strategy problems in a two-day workshop and apply concepts & methods from the Strategic Management course to develop suitable solutions.

**Content**

The course consists of two workshop days. However, most work for participants takes place in the phase between the two workshop days when participants engage in group work to solve a real-life strategic issue.

**First workshop day:**

Participants revisit core concepts and methods from the Strategic Management lecture. Moreover, participants learn the conceptual steps of defining strategic questions and developing suitable solutions for real-life settings. This conceptual process is then illustrated with an in-depth case study of a strategy consulting project that one of the lecturers conducted. The second part of the workshop day is the starting point for the group work phase. Participants identify a strategic problem that they face at work and team up. Each group consists of 4-6 participants to develop solutions by applying the concepts and methods from the Practicing Strategy class. At the end of the first workshop day, each group has defined one strategic question and developed a rough course of action for developing solutions until the second workshop day.

**Between workshop days:**

Participants work in small groups to develop solutions for the strategic problem that they identified on the first workshop day. This phase requires participants to select concepts and methods that are suitable to approach the strategic question. Moreover, students collect and analyze data. Subsequently, participants draw upon their analysis to develop solutions to the strategic problem. In this phase, participants can rely on the support and feedback from the teaching team.

**Second workshop day:**

Participants present their group work followed by an in-depth discussion and feedback session for each group project.

**Prerequisites / notice:**

Successful registration and participation (either parallel enrolment or successful completion in a previous semester) in the course “Strategic Management” is required (see Course Catalogue page for details).

### 365-1142-00L Understanding Human Behavior - Research and Business Insights

**Objective**

The course objective is to provide a crash-course of behavioral economics and decision science with a special focus on aspects particularly important in business and international companies. The aim of the course will be to apply theoretical knowledge obtained during the classes at ETH in practical business cases stemming from ETH industry partners.

**Abstract**

Human capital is the most precious resource of every company, while customers are the backbone of a company’s functioning. This course demonstrates applications of behavioral science theories to improve decision making within the company and to better understand its customers. In this course, psychology meets finance, data science and analytics to address practical business problems.

**Content**

This class is taught ‘by practitioners for practitioners’ with the final module focused on a customized Framework of Application introduced during prior modules. You will bring your priority challenge to the class, and through small group work and individual coaching, you will develop a plan of action. A final ‘elevator speech’ will give immediate feedback with which you can enhance the plan and apply it immediately back in your organization.

Separately, the D-MTEC MAS Mentoring Programme is available, should you desire continuing help to support your planning and execution after the course, or more generalized career development ideas.

### Literature

Literature and readings will be announced beforehand.

### 365-1166-00L Lean Production

**Objective**

After taking this course, students will be able to:

1. Operationalize and apply the just-in-time principle in manufacturing
2. Design a production system that minimizes quality errors
3. Work in a team to solve problems with selected problem-solving tools
4. Understand the role of behaviours and leadership in lean transformations
5. Select and apply new Industry 4.0 technologies to support the lean transformation

**Abstract**

This course (i) introduces the fundamentals of Lean Production and (ii) shows how new Industry 4.0 technologies can support a lean transformation. Through lectures, hands-on serious games, reflection and discussions, students learn (i) how lean production differs from other forms of production and (ii) how lean in synergy with new technologies can increase productivity in a production setting.

**Content**

This course is organized as a block course with two full lecture days. Day 1 focuses on the fundamental lean production principles and practices. Students get intimately familiar with lean production through a hands-on and immersive serious game and integrated reflection rounds. Day 2 focuses on how new technologies challenge and enhance the classic lean principles through presentations, hands-on exercises, and discussions. After each day, students write reflection notes with peer-review. The course is useful both for students with no previous experience of lean as well as for students with extensive experience of lean.
This block course is divided into three sessions:

1. Theory Part: Students get familiar with the Nobel-Prize winning theories, key concepts, models and findings in decision science and behavioral economics. The covered topics include judgment and decision making, heuristics, biases and heuristics, nudges, psychometrics, risk appetite elicitation, digital and physiological footprints of decisions, and impact of emotions and environment on decisions. The material will be aligned with relevant real-life examples that relate to important societal and business problems. The students will be introduced to the behavioral study design, behavioral analytics and research methods that can be applied in a business environment accounting for its advantages and limitations.

2. Business Insights Part: In this part students learn how the behavioral aspects enter into business processes, workflows and customer relations. An industry partner (Swiss Re) will present a business case related to behavioral science. Students challenge these cases in groups based on the theoretical part and guidance from lecturers. Students will form groups to solve the business case, using the knowledge acquired during the theoretical part of the course and relevant course material.

3. Final Presentation Part: This session will take place at the industry partner’s venue, where the students will present their business case solutions.

Attendance during the meetings and solving the business case are mandatory requirements for successful completion of the course.

Course material includes the lecture slides and scientific papers.

**Content**

**365-1067-00L** (Un)ethical Decision Making: Alternative and Critical Thinking in Management

*Exclusively for MAS MTEC students (3rd semester).*

*Please register by 24.08.2022 at the latest via myStudies.*

**Abstract**

This course is about decision making processes in complex situations involving financial, relational and ethical problems. First, it provides fundamental tools for addressing problematic situations.

Second, it discusses how stakeholders’ ethical expectations and social responsibility issues can be effectively implemented and integrated in organizational systems and strategic planning processes.

**Objective**

- Become familiar with tools and procedures to prevent, identify and resolve corporate fraud and crime in organizations
- Understanding the mutual relationship between financial, relational and ethical drivers in managerial decision making
- Become familiar with tools and procedures to prevent and resolve corporate crises and scandals
- Understanding the opportunities associated with the corporate social responsibility (CSR) movement and how to integrate CSR in organizational and strategic planning
- Create an effective CSR strategic planning process to successfully develop and implement a CSR package
- Understand a variety of strategic CSR planning tools
- Become familiar with creating deep destructive change in pursuit of dual economic and social value

**Content**

Why incredibly intelligent people do incredibly stupid things? What are the most frequent dynamics associated with corporate fraud and corruption? What should be done to avoid mobbing or discrimination in organizations? And how organizational crises can be prevented and eventually resolved? What is cosmetic corporate social responsibility?

On a more positive tone, how companies could create a culture that fosters personal and professional development? How do companies contribute to the development of societies where they operate? How do they contribute to alleviate the global problems and to promote a sustainable development?

This course will address these questions through case discussions, lectures and the presentations of invited speakers.

The main objective is to develop multiple, alternative, provocative, critical but constructive, perspectives of main ethical issues affecting the management of organizations today. We will “think out of the box”, learn how to look using the different perspectives of multiple stakeholders, take the defense of forgotten people, look at corporate power as an opportunity for organizational and social welfare… said in other terms, this is a course to think alternatively and creatively!

**Lecture notes**

Classes are taught through a series of cases that represent real management decisions. Students are required to prepare all of the assigned cases carefully before each class, to participate actively, and to respond thoughtfully to classmate comments.

Students will also work in teams to analyse and address ethical dilemmas, and strategic decisions involving ethical, environmental or societal issues.

**Literature**

This course is based on mini-cases.

**363-0861-00L** Alliance Advantage - Exploring the Value Creation Potential of Collaborations

*Exclusively for MAS MTEC students (3rd semester).*

**Abstract**

The development of new business models coping with the constantly augmenting complexity of technologies and systems as well as the ever increasing global competition force organizations to focus on close collaboration with key partners. These alliances are key value creation opportunities and constitute the core part of this lecture.

**Objective**

Learning outcomes professional competence
- The students learn and understand the management basics of inter-firm cooperation and organizational networks (business models, incl. risk, communication, etc.)
- Realize the value creation potentials of alliances (added value)
- Understand underlying theoretical models (Transaction cost theory, principal agent, game theory)
- Identify and understand specific forms of collaboration (Strat. All., JV, Networks, M&A, etc.)
- Apply tools hands on in real companies (in coll. with companies)

Learning outcomes methodological competence
- Writing academic papers
- Developing structured documentation of interviews
- Transferring theory directly into application
- Contributing to the learning journey

Learning outcomes social competence
- Work together with industrial partners
- Improving communication skills as basics for collaboration
- Developing and applying team work skills
- Coping with conflicts resolution in teams
The course is a combination of lectures about concepts/methods, guest lectures, case studies, and individual assignments. The seminar “Cases in Technology Marketing” introduces students to key concepts and tools in technology marketing and familiarizes them with the challenges that (marketing) managers face in technology intensive markets by using real life cases.

**Objective**

1. Understanding and applying common business tools and frameworks
2. Understanding current challenges of managers in technology intensive markets
3. Defining and analyzing comprehensive business problems using the example of a leading Swiss manufacturing company (Bühler AG)
4. Developing and evaluating different alternative case solutions
5. Making decisions on case solutions, justifying and defending them
6. Transferring case solutions into practice by formulating specific instructions for the management
7. Creation of novel, innovative ideas that help the company to gain a competitive edge
8. Cooperation in teams and coordination of team tasks
9. Adequate communication to and eye-level discussions with C-level managers

**Content**

The seminar “Cases in Technology Marketing” introduces students to key concepts and tools in technology marketing and familiarizes them with the challenges that (marketing) managers face in technology intensive markets by using real life cases. Students will have to work in groups and together solve past, current and future managerial problems in the form of cases. The team member composition will rotate for each case, enabling students to foster their teamwork abilities besides the application of theoretical concepts to the applied case questions. The students will have to present their case solutions to the lecturer and a top executive of a leading Swiss company (details see below). Also, they will be enabled to compare their solutions with what has actually been done or is yet to be done.

The three case studies presented in this course cover real managerial issues of the Swiss manufacturer Bühler AG (www.buhlergroup.com). A Bühler top executive will present the cases and discuss the students' presentations and solutions. As such, the course allows for in-depth discussions of the real-life case solution with the C-level manager and hereby enables students to transfer their learnings from theoretical considerations to the applied field. The course will be rounded off with a day-visit to the Bühler facilities in Uzwil, Switzerland, where students will have the chance to further connect with management and discuss the acquired key concepts, tools, and case study insights on site.

**Prerequisites / notice**

In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 20.08.2021 to Theresa Schachner: tschachner@ethz.ch.

Please register through myStudies to enroll for the course. Slots are assigned on a first-come first-serve basis (in the order of the registration date on myStudies). We will confirm your registration by e-mail. If you have any inquiries about the course, please contact the course assistant.

**Abstract**

This course focuses on the challenges in managing multi-business corporations, and covers topics related to the vertical and horizontal scope of business activities.

**Objective**

The course is a combination of lectures about concepts/methods, guest lectures, case studies, and individual assignments.
Large- and medium-sized corporations play a central role in the economic activity of most developed and developing countries. Many of these organizations perform multiple business activities in multiple markets. In the face of increasing international competition, globalization, technological development, deregulation, and the emergence of new markets and industries, operating such a portfolio of business activities poses important managerial challenges forcing corporations to continuously re-consider their vertical and horizontal scope and boundaries.

The course Corporate Strategy draws from a wide range of theories and methods to develop an understanding of the conceptual frameworks, debates, and developments concerning decisions associated with the management of multi-business corporations. We will cover the key questions driving a firm’s corporate strategy, including:

- In what markets to compete with which businesses?
- Which activities should be performed by the firm and which should be outsourced (i.e. "make" or "buy" decisions)?
- What are the most appropriate approaches to growth and divestiture?
- How do institutional forces impact corporate strategy?

Specifically, we will examine how organizations manage their portfolio of business activities and markets to achieve competitive advantage through vertical integration, cooperative strategies such as strategic alliances and joint ventures, corporate diversification, mergers and acquisitions, divestitures, and globalization/international strategies, and strategic renewal.

Prerequisites / notice

The course homepage can be found at: http://www.smi.ethz.ch/education/corporate-strategy.html

Having participated in the course Strategic Management by Prof. Georg von Krogh/Dr. Stephan Herting is an advantage but not a requirement.

Developing Digital Biomarkers

Particularly suitable for students with a technical background who are interested in healthcare.

Developing Digital Biomarkers

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:

- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1. Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2. Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer-centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3. Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4. Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

Digital Health Project (University of Zurich)

Does not take place this semester.

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: xxxxx
Today, we face the challenge of non-communicable diseases. Personal coaching approaches are neither scalable nor financially sustainable. The question arises therefore to which degree digital health interventions are appropriate to address this challenge. Students will design a just-in-time adaptive intervention.

The increasing prevalence of non-communicable diseases (NCDs) leads to the important question of how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, information systems research, computer science, and behavioural medicine, this last module of the CAS has the objective to help course participants to understand better the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions. After the module, participants will be able to understand better the...

1. design of a just-in-time adaptive intervention for the prevention of NCDs
2. technical implementation of a just-in-time adaptive intervention
3. evaluation of a just-in-time adaptive intervention.

Can medical Alexas make us more healthy? (The New York Times, April 2021), Wearables as a tool for measuring therapeutic adherence

The increasing prevalence of non-communicable diseases (NCDs) leads to the important question of how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, information systems research, computer science, and behavioural medicine, this last module of the CAS has the objective to help course participants to understand better the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions. After the module, participants will be able to understand better the...

1. design of a just-in-time adaptive intervention for the prevention of NCDs
2. technical implementation of a just-in-time adaptive intervention
3. evaluation of a just-in-time adaptive intervention.

What are the implications and rationale behind the recent developments in the field of digital health?

Digital Health is the use of information and communication technology for the prevention and treatment of diseases in the everyday life of individuals. It is thus linked to topics such as digital health interventions, digital biomarkers, digital coaches and healthcare chatbots, telemedicine, mobile and wearable computing, self-tracking, personalized medicine, connected health, smart homes, or smart cars.

In the 20th century, healthcare systems specialized in acute care. In the 21st century, we now face the challenge of dealing with the specific characteristics of non-communicable diseases. These are now responsible for around 70% of all deaths worldwide and 85% of all deaths in Europe and are associated with an estimated economic loss of $7 trillion between 2011 and 2025. Chronic and mental diseases are characterized in particular by the fact that they require an intervention paradigm that focuses on prevention and lifestyle change.

Lifestyle (e.g., diet, physical activity, tobacco, or alcohol consumption) can reduce the risk of suffering from a chronic condition or, if already present, can reduce its burden. A corresponding change in lifestyle is, however, only implemented by a fraction of those affected, partly because of missing or inadequate interventions or health literacy, partly due to socio-cultural influences. Individual personal coaching of these individuals is neither scalable nor financially sustainable.

To this end, the question arises on how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, behavioral medicine, information systems research, and computer science, this CAS module has the objective to help participants understand the interdisciplinary field of digital health to understand better the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions (JITAIs).

After the module, participants will be able to understand better the...

1. design of a JITAI for the prevention of NCDs
2. technical implementation of a JITAI
3. evaluation of a JITAI.

Course structure

The lecture is structured in two parts and follows the concept of a blended treatment consisting of online-based self-learning sessions and complementary “coaching” sessions via Zoom. In the first part, participants will learn about the topics of the three learning modules in weekly online sessions. Complementary learning material (e.g., video clips), multiple-choice questions, and exercises are provided online via Moodle. In the second part, students work in teams and will use their knowledge from the first part to develop a smartphone-based and chatbot-delivered JITAI with MobileCoach (www.mobile-coach.eu), an open-source software platform for digital interventions and ecological momentary assessments. Each team will then present and discuss their resulting JITAI and evaluation results with their fellow students who will provide peer-reviews. Additional online coaching sessions are offered to support the teams with the design and evaluation of their JITAI, and with the preparation of their presentations.

Literature

The students would cover the following topics, as they build their ideas into a business case:

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
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<tr>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Sensitivity to Diversity</td>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
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<td>Negotiation</td>
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<td>Self-direction and Self-management</td>
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### Prerequisites / notice

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they do not have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch

### Content

The students would cover the following topics, as they build their idea into a business case:

1. Technology excellence: This assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: A startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders' agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

### Literature

- Book
  - Sethi, A. "From Science to Startup"
  - ISBN 978-3-319-30422-9

### Enabling Entrepreneurship: From Science to Startup W 3 credits 2V A. Sethi

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.
<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Method-specific Competencies</th>
<th>Media and Digital Technologies</th>
<th>not assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</table>

### 363-1028-00L Entrepreneurial Leadership ■

**Limited number of participants.**

Students apply for this course via the official website no later than 21.08.2022 (https://www.mtec.ethz.ch/studies/special-programmes/els.html). Once your application is confirmed, registration in myStudies is possible.

**Abstract**

This seminar provides master and PhD students at MTEC with the challenging opportunity of a real case on strategy, innovation and leadership in close collaboration with the senior management of a leading Swiss healthcare company: F. Hoffmann-La Roche AG.

**Objective**

The general objective of the course is to enable MTEC students to develop leadership skills by dealing with real-world business problems, thinking critically about the concepts discussed in their study programs and learning how to apply these concepts to provide practical implications. It provides students with coaching and mentoring from senior leaders in the company and professors from D-MTEC to bridge the gap between theory and practice.

**Content**

This seminar provides ambitious ETH students and doctoral candidates with a rewarding learning opportunity: a real case study of strategy and innovation in close collaboration with the top management of an outstanding company: Georg Fischer.

**What you can expect:**

You will work in teams on specific high priority assignments that flow from the company. Delving into the assignments you will both contribute to solving strategic issues and have an impact on their implementation at the company.

To gain insight into the company and its culture you will receive briefings from senior management, conduct interviews with experts and run workshops with your case managers. In the final presentations you will pitch your findings to key stakeholders and top management representatives and receive valuable feedback.

Furthermore you will be coached and supported by MTEC professors on the topics of project scoping, problem definition and solving, process improvement, strategy and board presentation.

The course is directed and organised by PD Dr. Zeynep Erden and Dr. Isabel Spicker as part of the MTEC Leadership Development Programme.

**What we expect from you:**

You are an ambitious ETH student or doctoral candidate who is looking for a rewarding learning opportunity and is eager to go the extra mile. You will work on a real case study of strategy, technology and innovation in close collaboration with the top management of an outstanding Swiss company. The recommendations that you formulate in collaboration with members of your team as well as with internal and external experts will be discussed at the Partner and Director levels. This demands a deep understanding of the company's leadership culture.

In this endeavour you are coached and supported by

- Stefano Brusoni, Chair of Technology and Innovation Management
- Georg von Krogh, Chair of Strategic Management and Innovation
- Torbjörn Netland, Chair of Production and Operations Management
- Zeynep Erden, Lecturer, D-MTEC

**Literature**

Literature and readings will be announced in the coaching sessions.

**Prerequisites / notice**

Please apply for this course via the official website (https://mtec.ethz.ch/studies/programme-elements/special-programmes/els.html). Apply no later than August 22.

The number of participants is limited to 18.

ECTS: 4

Participants receive a certificate.

### 363-0887-00L Management Research ■

**Participation in both sessions and completion of all assignments is required to receive the credit.**

This course requires preparation time and completion of an assignment before the first course day. Please check the Moodle course page for more information.

**Abstract**

Students learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop their own research projects.

**Objective**

You will learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop your own research project. The successful completion of the course will help you to:

- Think critically and make compelling arguments about the strengths and weaknesses of published management research
- Find and review appropriate literature and previous research for your thesis
- Develop and frame interesting and relevant research questions and problem statements
- Design your research and choose an appropriate methodology for analysis (specific research methods and techniques are not discussed in this course)
- Structure your manuscript
- Plan and manage your thesis project

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Media and Digital Technologies</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social competencies</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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**Data:** 18.08.2022 12:39  
**Autumn Semester 2022**  
**Page 1457 of 2345**
This course combines lectures, group discussions and individual assignments.

Day 1: Introduction, group analysis exercises and discussions, lectures on main topics. Between course days 1 and 2: Individual and group work on assignments.

Day 2: Assignment review and discussion, lectures on main topics, conclusion session.

Target audience:
The course is designed with two groups of students in mind: first, students who write their master thesis at the SMI chair and second, students who write their master thesis in the field of management at other MTEC chairs.

For both groups, the focal topics of this course will arise frequently during the journey of writing their thesis, and the majority of topics are relevant for all students. However, we will provide some specific content (grading guidelines, thesis format) which might not be applicable for students tutored at other MTEC chairs.

Course topics:
1. Thesis topic and thesis proposal:
   - Choice of thesis topic, identification of research gap, formulation of research questions, writing of thesis proposal
2. Literature review:
   - Search and evaluation of academic literature, use of reference tools, writing of theoretical background chapter of thesis
3. Empirical research design:
   - Types of empirical research designs, choice of methodology, overview of data collection and analysis methods
4. Research output and report:
   - Writing of introduction, results and conclusion, thesis format and structure
5. Thesis assessment:
   - SMI grading criteria, MTEC guidelines

References:

Prerequisites / notice
This course is for all students who write their master thesis at the Department of Management, Technology, and Economics.

The course is required for all M.Sc. students and MAS students who write their master thesis at the Chair of Strategic Management and Innovation.

The course is graded based on the assignments, peer feedback, and participation in group discussions.

The first assignment is due before the first course day. Please check the assignments on the Moodle coursepage. If you sign up for the course on short notice before the first course day, please advise the lecturer of your registration by email.

Content
This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

This course is required for all M.Sc. students and MAS students who write their master thesis at the Chair of Strategic Management and Innovation.

The course is graded based on the assignments, peer feedback, and participation in group discussions.

The first assignment is due before the first course day. Please check the assignments on the Moodle coursepage. If you sign up for the course on short notice before the first course day, please advise the lecturer of your registration by email.

363-0311-00L Psychological Aspects of Risk Management and Technology W 3 credits 2V G. Grote, N. Bienefeld-Seall, R. Schneider, M. Zumbühl

Objective
Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are treated. Three components of risk management (risk identification/evaluation, risk mitigation, risk communication) and underlying psychological and organizational processes are discussed, using company case studies to promote in-depth understanding.

- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organisations
- Know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Group projects related to company case studies

Lecture notes
There is no script, but slides will be made available before the lectures.

Literature
There are texts for each of the course topics made available before the lectures.

Prerequisites / notice
The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).
Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.
Content

12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

Lecture notes

Lecture slides and case material

see elective courses MTEC MSc

▶ Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>365-1170-00L</td>
<td>Epigeum’s Avoiding Plagiarism Online</td>
<td>O</td>
<td>0</td>
<td>external organisers</td>
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<tr>
<td></td>
<td>course exclusively for MAS MTEC students. Further information will be provided after course registration via myStudies.</td>
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<tr>
<td>Abstract</td>
<td>Epigeum’s Avoiding Plagiarism Online Course covers the basics on how to avoid intentional as well as unintentional plagiarism and how to correctly use citations and references.</td>
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<tr>
<td>Objective</td>
<td>The course should be considered as the minimum knowledge standard. Especially for students with less expertise in structuring and writing academic texts we recommend to attend specifically designed preparation courses which provide a more comprehensive and in-depth guidance (please see Study Plan and Master Thesis Guidelines).</td>
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<tr>
<td>Content</td>
<td>This course is designed to help you understand what plagiarism is and how to avoid it. The key features of the course include:</td>
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<td></td>
<td>• Interviews with students and tutors sharing their thoughts on plagiarism</td>
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<td></td>
<td>• Key terms and different types of plagiarism explained</td>
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<td></td>
<td>• Interactive activities to help you learn what plagiarism is</td>
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<td></td>
<td>• Interactive activities to help you practise how to correctly cite and reference different sources</td>
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<td>• Strategies to help you develop an action plan to avoid plagiarism</td>
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<td>• Online resources to help extend your learning, including articles on real-life cases of plagiarism.</td>
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</table>

Prerequisites / notice

Plagiarism guidelines defined by ETH Zurich are authoritative.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>365-0899-00L</td>
<td>Master's Thesis in a Company</td>
<td>O</td>
<td>12</td>
<td>24D</td>
<td>Professors</td>
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<td>Exclusively for MAS MTEC students.</td>
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<tr>
<td>Abstract</td>
<td>In the Master thesis students prove their ability to independent, structured and scientific working. In the Master’s thesis students prove their ability to do independent, structured and scientific work. The Master’s thesis is written in collaboration with an industrial partner, organisation or institution and is supervised by an MTEC professor and a company supervisor.</td>
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<tr>
<td>Objective</td>
<td>Company supervisor: The Master’s thesis is written in collaboration with an industrial partner, organisation or institution (all of which may be referred to as a company in the following). A company employee acts as external supervisor for the Master’s thesis.</td>
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<td>Supervising professor: In addition to a company supervisor, you need a D-MTEC professor to serve as the main supervisor of your thesis.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The topic has to address a concrete problem affecting either your current employer or another company.</td>
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<td></td>
<td>You have to fulfil the following requirements before you can register for a Master’s thesis:</td>
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<td></td>
<td>– You must have passed the “365-1170-00L Epigeum’s Avoiding Plagiarism Online Course” which covers anti-plagiarism topics and citation rules in your 1st semester of study. Handling the intellectual property of others is not only an integral part of the Master’s thesis, but also a part of every semester paper you will write at ETH.</td>
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<td></td>
<td>– You must have read the “Citation Etiquette” information sheet on plagiarism (<a href="https://ethz.ch/content/dam/ethz/special-interest/study-programme-websites/mas-mtec-dam/Education/education-files/Citation%20etiquette%20-%20plagiarism-citationetiquette.pdf">https://ethz.ch/content/dam/ethz/special-interest/study-programme-websites/mas-mtec-dam/Education/education-files/Citation%20etiquette%20-%20plagiarism-citationetiquette.pdf</a>)</td>
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</table>

MAS in Management, Technology, and Economics - Key for Type

| O  | Compulsory          | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z  | Courses outside the curriculum |
| W  | Eligible for credits | Dr | Suitable for doctorate |

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1460 of 2345
### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Medical Physics

► Compulsory Courses (for both Specialisations)

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>465-0057-00L</td>
<td>Anatomy and Physiology for Medical Physicists I</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>F. Kuhn</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to structure and function of the human body. The lectures will be based on current clinical practices in Radiology, Neuroradiology and Nuclear Medicine.</td>
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<tr>
<td>Objective</td>
<td>Physiological and anatomical knowledge of the human body to ensure the correct understanding of basic concepts and to facilitate the collaboration of medical physicists and other health professionals.</td>
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<tr>
<td>Content</td>
<td>'Anatomy and physiology for medical physicists I &amp; II' provides insights into structure and function of the human body. The content is presented in an accessible manner targeted to physicist working in a medical setting. The lectures will be based on current clinical practices in Radiology, Neuroradiology and Nuclear Medicine. After an introduction to cells and tissues the following topics will be addressed: 1) Support &amp; Movement (musculoskeletal system, biomechanics); 2) Neuroscience (central and peripheral nervous system); 3) Auto-regulation (endocrine system) &amp; Internal Transport (blood &amp; cardiovascular system); 4) Environmental Exchange (respiratory, urinary, digestive &amp; reproductive system).</td>
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| 465-0953-00L| Biostatistics                                    | O    | 4    | 2V+1U | B. Sick   |
| Abstract    | The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests. Measurement of agreement, causality versus association. |      |      |       |           |
| Objective   | - know the commonly used methods in biostatistics  
- perform simple data analysis with R |      |      |       |           |

| 227-0385-10L| Biomedical Imaging                              | O    | 6    | 5G    | S. Kozerke, K. P. Prüssmann |
| Abstract    | Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques. |      |      |       |           |
| Objective   | To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts. |      |      |       |           |
| Content     | - X-ray imaging  
- Computed tomography  
- Single photon emission tomography  
- Positron emission tomography  
- Magnetic resonance imaging |      |      |       |           |
| Lecture notes | Lecture notes and handouts |      |      |       |           |
| Literature  | Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011 |      |      |       |           |
| Prerequisites / notice | Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming |      |      |       |           |

| 465-0966-00L| Physics in Radiodiagnostic and Nuclear Medicine | O    | 2    | 3G    | F. Bochud |
| Abstract    | The course is dedicated to introduce MAS students from Medical Physics to the field of radiodiagnostic and nuclear medicine. Dedicated practicals will illustrate the relationship between dose and image quality as well as the security problems related to the work with radiations. |      |      |       |           |
| Objective   | This 1-week theory and practical class offers the possibility to enjoy a variety of research and clinical areas in radiographic and nuclear medicine. It gives insight into practical concepts and techniques that are discussed thoroughly as the class is performed within actual laboratories with real radiation sources. |      |      |       |           |
| Content     | The course starts with the physical basis of radiography (from X-ray production to image detectors) and continues with the basic parameters of image quality in radiography (contrast, resolution, noise) and their measurement methods. Specific applications of radiation diagnostics are then considered separately. The physics of fluoroscopy and mammography is presented with emphasis on the type of detectors. Computer tomography starts from mono- to multi-detector row technology and finishes with the dose indicators and the impacts of acquisition parameters on patient dose. Nuclear medicine is approached through the production and labelling of radiopharmaceuticals before explaining the aspects related to quality control like the stability of the compounds, nuclide- and radionuclide purity as well as a-pyrogenicity and sterility. Imaging aspects of nuclear medicine are treated in details for SPECT and PET through the instrumentation, the reconstruction algorithms and the corresponding image quality. Finally, the aspects related to patient dose and radiation protection of the personnel are considered separately for diagnostic radiology and nuclear medicine. The general frameworks of external as well as internal irradiation are presented and practical examples of dose calculations are explained. |      |      |       |           |

► Specialisation in Radiation Therapy

►► Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>O</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.</td>
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<tr>
<td>Lecture notes</td>
<td>A script will be provided.</td>
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</tbody>
</table>

Data: 18.08.2022 12:39   Autumn Semester 2022   Page 1462 of 2345
By the end of this course the participants will be able to:

Radiobiology

By the end of this course the participants will be able to:

---

Dosimetrie in der Strahlentherapie. Planung und Durchführung einer perkutanen Strahlenexposition an einem anthropomorphen Phantom.

---

2V+1U

---

Einführung in die Strahlenbiologie ionisierender Strahlen: Allgemeine Grundlagen und Begriffsbestimmungen; Mechanismen der biologischen Strahlenwirkung; Strahlenwirkung auf Zellen, Gewebe und Organe; Modifikation der biologischen Strahlenwirkung; Strahlenzytopathologie: Chromosomenveränderungen, DNA-Defekte, Reparaturprozesse; Molekulare Strahlenbiologie: Bedeutung inter- und intrazellulärer Signalübermittlungsprozesse, Apoptose, Zellzyklus-Checkpoints; Strahlenrisiko, Strahleninduktion, Mutationsauslösung, pränatale Strahlenwirkung; Strahlenbiologische Grundlagen des Strahlenschutzes; Nutzen-Risiko-Abwägungen bei der medizinischen Strahlenanwendung; Prädiktive strahlenbiologische Methoden zur Optimierung der therapeutischen Strahlenanwendung.

---

Beilagen mit zusammenfassenden Texten, Tabellen, Bild- und Grafikdarstellungen werden abgegeben

---

The purpose of this course is to impart basic knowledge in radiobiology in order to handle ionizing radiation and to provide a basis for predicting the radiation risk.

---

By the end of this course the participants will be able to:

a) interpret the 5 Rs of radiation oncology in the context of the hallmarks of cancer
b) understand factors which underpin the differing radiosensitivities of different tumors
c) follow rational strategies for combined treatment modalities of ionizing radiation with targeted agents
d) understand differences in the radiation response of normal tissue versus tumor tissue
e) understand different treatment responses of the tumor and the normal tissue to differential clinical-related parameters of radiotherapy (dose rate, LET etc.)

---

For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

---

The purpose of this course is to impart basic knowledge in radiobiology in order to handle ionizing radiation and to provide a basis for predicting the radiation risk.

---

By the end of this course the participants will be able to:

a) interpret the 5 Rs of radiation oncology in the context of the hallmarks of cancer
b) understand factors which underpin the differing radiosensitivities of different tumors
c) follow rational strategies for combined treatment modalities of ionizing radiation with targeted agents
d) understand differences in the radiation response of normal tissue versus tumor tissue
e) understand different treatment responses of the tumor and the normal tissue to differential clinical-related parameters of radiotherapy (dose rate, LET etc.).

---

Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to predicting the radiation risk.

---

The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerators, and different radioactive sources in radiology, radiotherapy, and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

---

The former number of this course unit is 465-0951-00L.
### Practical Work

<table>
<thead>
<tr>
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<th>Type</th>
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<tr>
<td>465-0956-00L</td>
<td>Dosimetry</td>
<td>W</td>
<td>4 credits</td>
<td>6G</td>
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<tr>
<td>Abstract</td>
<td>Dosimetry in radiotherapy. Planning and implementation of a percutaneous radiation exposure on an anthropomorphic phantom. Verification of the resulting dose distribution.</td>
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<tr>
<td>Objective</td>
<td>Praktische Umsetzung der Lerninhalte der Vorlesungen Medizinische Physik I &amp; II bezüglich Dosimetrie bei perkutanen Strahlenexpositionen Überprüfung der resultierenden Dosisverteilungen.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Dosimetrie in der Strahlentherapie. Planung und Durchführung einer perkutanen Strahlenexposition an einem anthropomorphen Phantom.</td>
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<tr>
<td>Lecture notes</td>
<td>Die Kursunterlagen werden im Blockkurs abgegeben.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Voraussetzung: Besuch der Vorlesung Medizinische Physik I</td>
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### Electives

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<tr>
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<tr>
<td>227-0965-00L</td>
<td>Micro and Nano-Tomography of Biological Tissues</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Stamparini, F. Marone Welford</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture introduces the physical and technical knowledge of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.</td>
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<tr>
<td>Objective</td>
<td>Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.</td>
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<tr>
<td>Content</td>
<td>Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples. The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments. The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.</td>
<td></td>
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<td>Lecture notes</td>
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<td>Literature</td>
<td>Will be indicated during the lecture.</td>
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<th>Hours</th>
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<tr>
<td>227-0941-00L</td>
<td>Physics and Mathematics of Radiotherapy Planning (University of Zurich)</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>University lecturers</td>
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<tr>
<td>Objective</td>
<td>This lecture will provide a detailed introduction to radiotherapy treatment planning. The course considers the physical interactions of radiation in tissue, the mathematical aspects of treatment planning and additional aspects of central importance for radiotherapy planning.</td>
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<tr>
<td>Content</td>
<td>Students shall develop a thorough understanding of the foundations of radiotherapy from a physics and mathematics perspective, focusing on algorithmic components. After completing the course students should be able to implement the main components of a radiotherapy treatment planning system.</td>
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Data: 18.08.2022 12:39

Autumn Semester 2022
Radiotherapy is one of the main treatment options against cancer. Today, more than 50% of cancer patients receive radiation as part of their treatment. Modern radiotherapy is a highly technology driven field.

Research and development in medical physics has improved the precision of radiotherapy substantially. Using intensity-modulated radiotherapy (IMRT), radiation can be delivered precisely to tumors while minimizing radiation exposure of healthy organs surrounding the tumor. Thereby, medical physics has provided radiation oncologists with new curative treatment approaches where previously only palliative treatments were possible. This lecture will provide a detailed introduction to radiotherapy treatment planning and will consists of three blocks:

1. The first part of the course considers the physical interactions of radiation in tissue. The physical interactions give rise to dose calculation algorithms, which are used to calculate the absorbed radiation dose based on a CT scan of the patient.

2. The second part considers the mathematical aspects of treatment planning. Mathematical optimization techniques are introduced, which are used in intensity-modulated radiotherapy to determine the external radiation fields that optimally irradiate the tumor while minimizing radiation dose to healthy organs.

3. The third part deals with additional aspects of central importance for radiotherapy planning. This includes biomedical imaging techniques for treatment planning and target delineation as well as image registration algorithms.

The lectures are followed by computational exercises where students implement the main components of a radiotherapy treatment planning systems in two dimensions in Matlab.

Lecture notes
Lecture slides and handouts.

Prerequisites / notice
Basic programming skills in Matlab (or willingness to learn) are needed for the exercises. Basic knowledge of calculus is needed, approximately corresponding to the 3rd year of a bachelor degree in physics, mathematics, computer science, engineering or comparable discipline.

402-0674-00L

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Physics in Medical Research: From Atoms to Cells</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>B. K. R. Müller</th>
</tr>
</thead>
</table>

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

Objective
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocytic behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinetic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of bioplas.

★★★ Major in Biomechanics
★★★★ Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.
Trauma Biomechanics
M. Stampanoni

This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, particularly world examples mainly from automobile safety are used to augment lecture material. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety, and real-world examples mainly from automobile safety are used to augment lecture material.

Micro and Nano-Tomography of Biological Tissues
F. Marone Welford

Measurement and modeling of the human movement during daily activities and in a clinical environment. The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments. The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice
No specific requirements, BUT HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from data acquisition to image formation through reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

Clinical and Movement Biomechanics
W 4 credits
M. Singh, R. List, P. Schütz

Abstract
Measurement and modeling of the human movement during daily activities and in a clinical environment.

Objective
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

Content
This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling with regards to human movement.

Trauma Biomechanics
W 4 credits
K.-U. Schmitt, M. H. Muser

Abstract
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

Objective
Introduction to the basic principles of trauma biomechanics.

Content
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety, real-world examples mainly from automobile safety are used to augment lecture material.

Lecture notes
Handouts will be made available.

Adaptability and Flexibility
Self-direction and Self-management
Social Competencies
Communication
Customer Orientation
Integrity and Work Ethics
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Critical Thinking
Creative Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Content

227-0965-00L Micro and Nano-Tomography of Biological Tissues W 4 credits M. Stampanoni, F. Marone Welford

Abstract

Objective

Content

227-1651-00L Clinical and Movement Biomechanics W 4 credits N. Singh, R. List, P. Schütz

Abstract

Objective

Content

227-1985-00L Trauma Biomechanics W 4 credits K.-U. Schmitt, M. H. Muser

Abstract

Objective

Content

Moodle page of the course
No specific requirements, BUT HT and BIOL students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Handouts will be made available.

Microrobotics

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available.

Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>465-0800-00L</td>
<td></td>
<td></td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

Abstract

The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

Objective

The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

Electives

<table>
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<th>Number</th>
<th>Type</th>
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<th>Lecturers</th>
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<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>A. E. Ehret</td>
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</table>

Abstract

The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective

Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.

Content

Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments.

Lecture notes

yes

Electives

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<tr>
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<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
</tbody>
</table>

Abstract

Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content

Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microfabrics

Lecture notes

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice

The lecture will be taught in English.

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<tr>
<th>Number</th>
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<td>376-2017-00L</td>
<td>Biomechanics of Sports Injuries and Rehabilitation</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>K.-U. Schmitt, J. Goldhahn</td>
</tr>
</tbody>
</table>

Abstract

This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries. Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

Objective

This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

Content

Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

Literature


Prerequisites / notice

A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

Major in Bioimaging

Core Courses
### Biomedical Engineering

**Course Title:** Biomedical Engineering  
**ECTS:** 4 credits  
**Lecturers:** J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

**Abstract:** Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective:** Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

**Content:** History of BME and the role of biomedical engineers. Ethical issues related to BME. Biomedical sensors both wearable and also biochemical sensors. Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices. Bioinformatics: genomic and proteomic tools, databases and basic calculations. Equations describing basic reactions and enzyme kinetics. Medical optics: Optical components and systems used in hospitals. Basic concepts of tissue engineering and organ printing. Biomaterials and their medical applications. Function of the heart and the circulatory system. Transport and exchange of substances in the human body, compartment modeling. The respiratory system. Bioimaging. Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes:** Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino  

AND  
moodle page of the course

**Prerequisites / notice:** No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).  

**Taught competencies**

<table>
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<tr>
<th>Competency</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
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<td>Critical Thinking</td>
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<td>Problem-solving</td>
<td>Project Management</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
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**Practical Work**

**Course Title:** Image Analysis and Computer Vision  
**ECTS:** 6 credits  
**Lecturers:** E. Konukoglu, F. Yu

**Abstract:** Light and perception. Digital image formation. Image enhancement and feature extraction. Unitary transformations. Color and texture. Image segmentation. Motion extraction and tracking. 3D data extraction. Invariant features. Specific object recognition and object class recognition. Deep learning and Convolutional Neural Networks.

**Objective:** Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content:** This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization from an analog to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Lecture notes:** Course material Script, computer demonstrations, exercises and problem solutions  

**Prerequisites / notice:** Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

Objective
The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

Electives

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<tr>
<th>Number</th>
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<td>151-0605-00L</td>
<td>Nanosystems</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Stemmer</td>
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Abstract
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.

Special emphasis on the emerging field of molecular electronic devices.

Objective
Familiarize students with basic science and engineering principles governing the nano domain.

Content
The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

Self-assembly and directed assembly of 2D and 3D structures.

(II) Interaction Forces on the Micro and Nano Scale
Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.

Prerequisites / notice
Course format:
Lectures and Mini-Review presentations: Thursday 10-13

Homework: Mini-Review (compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

227-0965-00L Micro and Nano-Tomography of Biological Tissues W 4 credits 3G M. Stampanoni, F. Marone Welford

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complete morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

227-0967-00L Computational Neuroimaging Clinic W 3 credits 3G K. Stephan

Prerequisite: Successful completion of course "Methods & Models for fMRI Data Analysis", "Translational Neuroimaging" or "Computational Psychiatry"

Abstract
This seminar teaches problem solving skills for computational neuroimaging, based on joint analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

Objective
1. Consolidation of theoretical knowledge (obtained in the following courses: 'Methods & models for fMRI data analysis', 'Translational Neuroimaging', 'Computational Psychiatry') in a practical setting.
2. Acquisition of practical problem solving strategies for computational modeling of neuroimaging data.

Content
This seminar teaches problem solving skills for computational neuroimaging, based on joint analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g.

mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

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Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), including preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

Objective
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

Abstract
As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitations of the materials studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

Objective
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Abstract
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

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The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Objective
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within mammal and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W</td>
<td>4 credits</td>
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<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>W</td>
<td>4 credits</td>
</tr>
<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4 credits</td>
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Abstract
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within mammal and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

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Practical Work

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**Abstract**
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

**Objective**
The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

Electives

**376-1622-00L Practical Methods in Tissue Engineering (offered in the Autumn Semester) and 376-1624-00L Practical Methods in Biofabrication (offered in the Spring Semester) are mutually exclusive to be eligible for credits.**

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<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>B. Nelson</td>
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**Abstract**
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

**Content**
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

**Lecture notes**
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

**Prerequisites / notice**
The lecture will be taught in English.

Biomedical Engineering

<table>
<thead>
<tr>
<th>Number</th>
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<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
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**Abstract**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**
- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes**
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

**Prerequisites / notice**
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Abstract
The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

Objective
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

Content
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Lecture notes
Script with more than 600 pages with many illustrations will be distributed free of charge.

Prerequisites / notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

376-1622-00L Practical Methods in Tissue Engineering W 5 credits 4P M. Zenobi-Wong, S. J. Ferguson, S. Grad, S. Schürle-Finke

Abstract
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Objective
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

402-0674-00L Physics in Medical Research: From Atoms to Cells W 6 credits 2V+1U B. K. R. Müller

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, organic and biological surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the (anisotropic) molecules studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to online monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

<table>
<thead>
<tr>
<th>535-0423-00L</th>
<th>Drug Delivery and Drug Targeting</th>
<th>W</th>
<th>2 credits</th>
<th>1.5V</th>
<th>J.-C. Leroux</th>
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<tbody>
<tr>
<td>Objective</td>
<td>The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.</td>
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<tr>
<td>Content</td>
<td>The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.</td>
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<tr>
<td>Literature</td>
<td>The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.</td>
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<tr>
<td>Taught competencies</td>
<td>Further references will be provided in the course.</td>
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<tr>
<th>227-0393-10L</th>
<th>Bioelectronics and Biosensors</th>
<th>W</th>
<th>6 credits</th>
<th>2V+2U</th>
<th>J. Vörös, M. F. Yanik</th>
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<tr>
<td>Objective</td>
<td>During this course the students will:</td>
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<tr>
<td>- learn the basic concepts in biosensing and bioelectronics</td>
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<td>- be able to solve typical problems in biosensing and bioelectronics</td>
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<td>- learn about the remaining challenges in this field</td>
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Further references will be provided in the course.
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

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**Core Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<td>Objective</td>
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<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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<td></td>
<td>Content</td>
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<td>Main topics of the course include:</td>
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<td>- Scaling laws at micro/nano scales</td>
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<td>- Electrostatics</td>
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<td>- Electromagnetism</td>
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<td>- Low Reynolds number flows</td>
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<td></td>
<td>- Observation tools</td>
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<td>- Materials and fabrication methods</td>
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<td></td>
<td>- Applications of biomedical microrobots</td>
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<td></td>
<td>Lecture notes</td>
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<td>The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.</td>
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<td>Prerequisites / notice</td>
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<td>The lecture will be taught in English.</td>
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| 227-0386-00L| Biomedical Engineering       | W    | 4    | 3G    | J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong |
|             | Abstract                     |      |      |       |                   |
|             | Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view. |
|             | Objective                    |      |      |       |                   |
|             | Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined. |
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

### Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.

Biomedical sensors both wearable and also biochemical sensors.

Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.

Bioinformatics: genomic and proteomic tools, databases and basic calculations.

Equations describing basic reactions and enzyme kinetics.

Medical optics: Optical components and systems used in hospitals.

Basic concepts of tissue engineering and organ printing.

Biomaterials and their medical applications.

Function of the heart and the circulatory system.

Transport and exchange of substances in the human body, compartment modeling.

The respiratory system.

Bioimaging.

Orthopedic biomechanics.

### Lecture notes

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

### Prerequisites / notice

No specific requirements, BUT HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.)

### Taught competencies

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### 227-1037-00L Introduction to Neuroinformatics

| W | 6 credits | 2V+1U+1A | V. Mante, M. Cook, B. Grewer, G. Indiev, D. Kiper, W. von der Behrens |

**Abstract**

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

**Objective**

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

**Content**

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

### 376-1714-00L Biocompatible Materials

| W | 4 credits | 3V | K. Maniura, M. Rottmar, M. Zenobi-Wong |

**Abstract**

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

(available online via ETH library)

Handouts and references therin.

227-0393-10L Bioelectronics and Biosensors W 6 credits 2V+2U J. Vörös, M. F. Yanik

Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field

Content
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons
L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications
L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes
L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing
L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory
L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes
L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)
L10. Channels, amplification, signal gating, and patch clamp Y4
L11. Action potentials and impulse propagation
L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation
L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Practical Work

Number Title Type ECTS Hours Lecturers
465-0800-00L Practical Work Only for MAS in Medical Physics O 4 credits 8 external organisers

Abstract
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

Objective
The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 ECTS.

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main 2V+3U

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After 2V+1U

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed 4V

Neuromorphic Engineering I

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano properties, novel technologies and new methods to address major medical challenges. Technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be collaborations.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across disciplinary boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different fields, and learn the vocabulary that is necessary to communicate effectively across disciplinary boundaries.

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module IN4/04 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulation of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, conductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Physical Modelling and Simulation

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS. In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within mammade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across disciplinary boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Biomicrofluidic Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0837-01L</td>
<td>W 6 credits 3G A. de Mello</td>
</tr>
</tbody>
</table>

**Objective**

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

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Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers. After this course students will be able to:

- read and understand the main ideas and methods that are presented in today’s neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al., 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

The lecture slides will be provided as a PDF after each lecture.
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina, silicon cochlea) and an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites
Particular: The course is highly recommended for those who intend to take the spring semester course 'Neuromorphic Engineering II', that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Abstract
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

Objective
The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

ECTS
4 credits

Prerequisites
Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>465-0800-00L</td>
<td>Practical Work Only for MAS in Medical Physics</td>
<td>O</td>
<td>4</td>
<td></td>
<td>external organisers</td>
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</tbody>
</table>

Abstract
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

Objective
The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu</td>
</tr>
</tbody>
</table>

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.
This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions. Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with applications in biology.

**Lecturers**
F. Marone Welford

The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

**227-1051-00L Systems Neuroscience (University of Zurich)**

*No enrollment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*

**UZH Module Code:** INI415

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

**Abstract**
This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions.

**Objective**
To understand the basic concepts underlying perceptual, motor and cognitive functions.

**Content**
Main emphasis sensory systems, with complements on motor and cognitive functions.

**Lecture notes**
None

**Literature**
“*Principles of Neural Science*, Kandel, Schwartz, and Jessel

**Prerequisites / notice**
none

### Major in Biocompatible Materials

### Core Courses

**376-1622-00L Practical Methods in Tissue Engineering (offered in the Autumn Semester) and 376-1624-00L Practical Methods in Biofabrication (offered in the Spring Semester) are mutually exclusive to be eligible for credits.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0965-00L</td>
<td>Micro and Nano-Tomography of Biological Tissues</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Stamponoli, F. Marone Welford</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>Synchrontron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.</td>
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<td>The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how image beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.</td>
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<td>The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<td>Available online</td>
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<td></td>
<td><strong>Literature</strong></td>
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<td>Will be indicated during the lecture.</td>
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<tr>
<td>376-1622-00L</td>
<td>Practical Methods in Tissue Engineering</td>
<td>W</td>
<td>5</td>
<td>4P</td>
<td>M. Zenobi-Wong, S. J. Ferguson, S. Grad, S. Schürle-Finke</td>
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<td><em>Number of participants limited to 12.</em></td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.</td>
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<td><strong>Objective</strong></td>
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<td>Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td>A Windows laptop (or Windows on Mac) is required for certain of the lab modules.</td>
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<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>K. Maniura, M. Rottmar, M. Zenobi-Wong</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.</td>
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<td><strong>Objective</strong></td>
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<td>The course covers the following topics:</td>
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<tr>
<td></td>
<td>1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.</td>
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<td>2. The concept of biocompatibility.</td>
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<td>3. Introduction into methodology used in biomaterials research and application.</td>
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<td>4. Introduction to different material classes in use for medical applications.</td>
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</table>
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Handouts are deposited online (moodle).

Handouts and references therein.

**Practical Work**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>465-0800-00L</td>
<td>Practical Work</td>
<td>O</td>
<td>4</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

**Abstract**
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

**Objective**
The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

**Electives**

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>327-1101-00L</td>
<td>Biomineralization</td>
<td>W</td>
<td>2</td>
<td></td>
<td>K.-H. Ernst</td>
</tr>
</tbody>
</table>

**Abstract**
The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

**Objective**
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

**Content**
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra-, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

**Literature**
Script with more than 600 pages with many illustrations will be distributed free of charge.

3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

**Prerequisites / notice**
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W</td>
<td>4</td>
<td></td>
<td>V. Vogel, further lecturers</td>
</tr>
</tbody>
</table>

**Abstract**
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

**Objective**
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nanochemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

402-0674-00L  
**Physics in Medical Research: From Atoms to Cells**  
W 6 credits 2V+1U  
B. K. R. Müller

**Abstract**  
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

**Objective**  
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

227-0393-10L  
**Bioelectronics and Biosensors**  
W 6 credits 2V+2U  
J. Vörös, M. F. Yanik

**Abstract**  
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

**Objective**  
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

376-1353-00L Nanostructured Materials Safety
<table>
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<th>Type</th>
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<th>Lecturers</th>
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<td>2</td>
<td>1V</td>
<td>P. Wick</td>
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Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Prerequisites / notice
Course “Introduction to Toxicology”

Major in Molecular Biology and Biophysics

Core Courses

Number | Title | Type | ECTS | Hours | Lecturers |
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<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>to be announced</td>
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Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes
Scripts of all lectures will be available.

Literature
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- maximum likelihood and Bayesian statistics
- phylogenetic & phylodynamic inference
- stochastic models in molecular evolution

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS.

Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture slides will be available on moodle.

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- * Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming”, which takes place in Basel before the start of the semester.

The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization. The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.
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9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Lecture notes

Script with more than 600 pages with many illustrations will be distributed free of charge.

Literature
3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

Prerequisites/
notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.
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Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.
Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biomedical and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

<table>
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<th>Tutor</th>
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<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W 4</td>
<td>3V</td>
<td>M. Fussenegger</td>
</tr>
</tbody>
</table>

Abstract
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content

Lecture notes
Handout during the course.

<table>
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<tr>
<th>Course Code</th>
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<th>Credits</th>
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<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W 6</td>
<td>4G</td>
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</tbody>
</table>

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

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<th>Course Code</th>
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<tbody>
<tr>
<td>3V</td>
<td>Physical Modelling and Simulation</td>
<td>3V</td>
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Content
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

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<tr>
<td>4G</td>
<td>Physical Modelling and Simulation</td>
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</table>

Current topics: References will be given during the lectures.
MAS in Future Transport Systems

Four-semester, part-time MAS programme.

Start of the next course: Spring Semester 2023.


Major in Systemic Aspects of Future Transport

The Major in “Systemic Aspects of Future Transport” takes place only in Spring Semester

Start of the next course: Spring Semester 2023

Course duration: Six months part time

Periodicity: Every two years

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<tr>
<th>Number</th>
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<td>166-0100-00L</td>
<td>Transport Systems: Dynamics and Future Developments</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Erath Rusterholtz, P. J. de Haan van der Weg</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Interrelationships and dynamic change and the impact of these on mobility and transportation are being investigated in this module. The module addresses desirable future development of urban transport systems in Switzerland by covering and critically examining authentic, existing transport scenarios (e.g. ARE) in an exercise setting which deploys backcasting.</td>
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<td><strong>Objective</strong></td>
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<td>- understand the complexity of the transport system status quo as a whole, and are able to describe it qualitatively and create an operational and/or working context (K1).</td>
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<td>- understand the development of transport systems and future transport scenarios over time, and can infer objectives from the latter (K2).</td>
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<td>- understand how digitalisation drives new mobility services (mobility as a service), and are able to qualitatively estimate the changes these bring to transport systems as a whole (K4).</td>
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<td>- are able to pinpoint the challenges and potential of the transition to autonomous transport forms (K5).</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>- Deepen understanding of complex transport systems and their dynamics past – status quo – future</td>
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<td>- Consolidate a foundation in the dynamics of transport systems: elements and their interrelationships</td>
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<td>- Overview and selection of methods/approaches for the development and analysis of scenarios</td>
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<td>- Future perspectives (ARE), target scenarios</td>
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<td>- Transformation and change in systems</td>
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<td>- Transport policy and the potential of regulation</td>
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<td>- Excursion: “Infrastructure to support active mobility: Bike capital Bern”</td>
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<td><strong>Methods selected</strong></td>
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<td></td>
<td>- System analysis, scenario analysis, foresight, indicators for sustainable mobility, Case studies, reading and discussion of thesis papers and scientific publications</td>
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Lecture notes: Distributed at start of module

Literature: Distributed at start of module

Prerequisites / notice: Announced to students of the of the MAS / CAS at the beginning of the term

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<tr>
<th>Number</th>
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<tr>
<td>166-0101-00L</td>
<td>Development and Assessment of Transport Scenarios</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>A. Erath Rusterholtz</td>
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<td><strong>Abstract</strong></td>
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<td>This module familiarises participants with current methods of developing and evaluating transport scenarios. These include analysis of the interrelationship of space and traffic; traffic modelling methods; and evaluation according to economic and planning criteria.</td>
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<td><strong>Objective</strong></td>
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<td>Participants</td>
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<td>- are familiar with suitable methods for developing transport scenarios and how to analyse and evaluate them. In particular, they know how to address the challenges of evaluating future forms of transport;</td>
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<td>- are able to select a suitable method and determine an evaluation concept with relation to a specific problem.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>- Methodological foundations of traffic modelling (44-level model, activity-based model, agent-based simulation)</td>
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<td></td>
<td>- Design and evaluation of transport scenarios using MATSim (traffic simulation) with a focus on transport with autonomous vehicles</td>
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<td></td>
<td>- Interrelationship of space and traffic (accessibility measurement, settlement density and mixed usage) and what to consider in designing and evaluating transport scenarios</td>
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<td>- Approaches to evaluation of traffic scenarios (cost-benefit analyses and their foundations, methodological limits), analysis of effects taking into account user group and space type</td>
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<td>- Ecobalancing with Life Cycle Assessment (LCA) in addressing passenger and goods transport issues</td>
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<td></td>
<td>- Development of case studies on shared transport and mobility with an activity- and agent-based transport simulation model</td>
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<td><strong>Methods</strong></td>
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<td>- Aggregated and activity-based transport demand models</td>
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<td>- Agent-based simulation</td>
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<td>- Cost-benefit analysis</td>
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<td>- Accessibility analysis</td>
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<td><strong>Case studies</strong></td>
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<td>- Shared mobility</td>
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<td>- Autonomous mobility</td>
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<td></td>
<td>- Densified settlement development and slow forms of mobility</td>
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Lecture notes: Distributed at start of module

Literature: Distributed at start of module

Prerequisites / notice: Announced to students of the of the MAS / CAS at the beginning of the term

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td>166-0102-00L</td>
<td>Foundations for the Design of Transport System Innovation and Change Processes</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Schippl</td>
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</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1491 of 2345
The participants deal with a current problem from the topics of CAS System Aspects.

**System Aspects of Air and Shipping Traffic**

**In this module,** innovation, change and transitions in transportation systems on different levels are discussed from different complementary perspectives. Both economic and social science approaches to the analysis, anticipation and governance of innovation processes are presented, discussed and applied to current issues. Topics are:

- Relevant theories and methods;
- Innovation as an economic discovery process, measuring innovation;
- Emerging trends as new opportunities for innovation;
- Innovation today in the transportation/mobility system: theoretical basis and concrete examples;
- Transition of socio-technical systems, co-evolution of technical and societal dynamics;
- The relevance of social acceptance and ethical aspects for innovations in mobility.

**Participants**

Are able to...

- Know the fundamental differences between air, shipping traffic compared to motorized individual transport and public transport.
- Are able to deduce differences between air and shipping traffic.
- Know the possibilities and limits as well as pros and cons of different valuation methods used for air and shipping transport.
- Develop ideas for suitable indicators to evaluate scenarios in air and shipping traffic.
- Key figures, development and trends in air and shipping traffic.
- Potentials for holistic improvement in air and shipping traffic.
- Life Cycle Assessment (LCA) for questions in air and shipping traffic.
- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Berechnung und Interpretation von Kennzahlen.

**Abstract**

Air and shipping traffic cover a substantial part of human mobility, air traffic in passenger as well as freight transport, shipping mainly in freight transport. Students gain an overview, limit modes of mobility and learn to classify air and shipping traffic in the overall system of mobility.

**Objective**

- Know the possibilities and limits as well as pros and cons of different valuation methods used for air and shipping transport.
- Develop ideas for suitable indicators to evaluate scenarios in air and shipping traffic.
- Key figures, development and trends in air and shipping traffic.
- Potentials for holistic improvement in air and shipping traffic.
- Life Cycle Assessment (LCA) for questions in air and shipping traffic.
- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Berechnung und Interpretation von Kennzahlen.

**Content**

- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Develop ideas for suitable indicators to evaluate scenarios in air and shipping traffic.
- Key figures, development and trends in air and shipping traffic.
- Potentials for holistic improvement in air and shipping traffic.
- Life Cycle Assessment (LCA) for questions in air and shipping traffic.
- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Berechnung und Interpretation von Kennzahlen.

**Lecture notes / Literature**

Announced to students of the of the MAS / CAS at the beginning of the term.

**Prerequisites / notice**

Distributed at start of module.

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**CAS Thesis on System Aspects**

**Abstract**

The participants deal with a current problem from the topics of CAS System Aspects.

**Objective**

- Develop selected content from module independently.
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

**Content**

- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Develop ideas for suitable indicators to evaluate scenarios in air and shipping traffic.
- Key figures, development and trends in air and shipping traffic.
- Potentials for holistic improvement in air and shipping traffic.
- Life Cycle Assessment (LCA) for questions in air and shipping traffic.
- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Berechnung und Interpretation von Kennzahlen.

**Lecture notes / Literature**

Announced to students of the of the MAS / CAS at the beginning of the term.

**Prerequisites / notice**

Distributed at start of module.

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**Major in Technology Potential**

The Major in "Major in Technology Potential" takes place only in Autumn Semester

Start of the next course: Autumn Semester 2023
Course duration: Six months part time
Periodicity: Every two years

**Number**

166-0200-00L

**Title**

Technology Potential: Powertrain, Systems and Energy Carriers

**Abstract**

The module provides a foundation in the current situation and short- and middle-term development directions of powertrain and automotive engineering in the context of passenger & goods transport. Corresponding energy sources and resulting consequences for the energy system are addressed. Participants will be enabled to identify potentials of these technologies and apply them to concrete problems.

**Objective**

Familiarity with conventional and alternative powertrain and automotive systems for future sustainable mobility, and the ability to identify and deploy their potential to address concrete problems.

**Number**

166-0190-00L

**Title**

CAS Thesis on System Aspects

**Abstract**

The participants deal with a current problem from the topics of CAS System Aspects.

**Objective**

- Develop selected content from module independently.
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

**Content**

- Develop selected content from module independently.
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

**Lecture notes / Literature**

Announced to students of the of the MAS / CAS at the beginning of the term.

**Prerequisites / notice**

Distributed at start of module.
Content
- Drive component efficiency rates and core fields
- Drive and non-drive energy flow / Vehicle "driving resistance"
- Energy chains (operating power only) and CO2 emissions to primary energy

Lecture notes Distributed at start of module
Literature Distributed at start of module
Prerequisites / notice Announced to students of the of the MAS / CAS at the beginning of the term

166-0201-00L Potential of Spatial Information- and Communication Technologies ■

Abstract
The digital revolution, spatial information and communication systems in particular, have a significant influence on the development of new transport systems. Participants acquire an in-depth understanding of the functionality and application potential of spatial information systems and services and of communication technologies for deployment in future transport systems and applications.

Objective
Familiarity with information and communication technologies (ICT) and spatial information technologies, and the ability to identify and utilise their potential to address concrete problems.

Content
- Functionality and application of geographic information systems (GIS) to represent and analyse transport systems (acquire, model, analyse and visualise geodata)
- Deployment potentials of GIS and ICT for efficient transport solutions (tangible, non-tangible)
- Functionality and application of mobile spatial information technologies in future transport systems
- Methods of spatiotemporal analysis and geodata analysis
- Technical aspects of information and communication technologies (ICT)
- Modelling, simulation and assessment of traffic behaviour
- Basics of autonomous driving
- Legal aspects of geodata
- Applications: Traffic behaviour in Switzerland; location based services for energy-efficient behaviour; GIS for the Zurich traffic system (multimodal)

Lecture notes Distributed at start of module
Literature Distributed at start of module
Prerequisites / notice Announced to students of the of the MAS / CAS at the beginning of the term.

166-0202-00L Integrated Assessment of Technologies and Transport Systems ■

Abstract
The module provides a solid introduction to integrated technology assessment with regard to economic, ecological and social criteria. It introduces life cycle assessment (LCA), cost assessment, risk assessment and multi-criteria decision analysis. It also presents scenario analyses based upon energy-economic models which explicitly represent transport and energy-supply technologies.

Objective
An overview of suitable methods for analysing and evaluating technical systems (transport systems) and the ability to choose among them to address concrete problems.

Content
(1) Introduction to and overview of integrated assessment
  - Current status of transport in Switzerland and internationally
  - Scope and goals of integrated assessment
  - Sustainability: concept and practical implementation via criteria and indicators
  - Overview of concepts and implementation methods

(2) Selected methods for assessing transport technologies and their application to current and future options
  - Ecobalance / life cycle assessment (LCA)
  - Location-specific assessment of health hazards and environmental pollution
  - Risk analysis
  - Internal cost assessment
  - External cost assessment

(3) Integrated assessment of transport technologies
  - Overall costs (internal and external)
  - Multi-criteria analysis

(4) Analysis of transport scenarios
  - Scenarios, influencing factors, policy and sustainability
  - Approaches to scenario modelling
  - Global mobility scenarios: examples
  - Transport scenarios for Switzerland using energy system models

Lecture notes Distributed at start of module
Literature Distributed at start of module
Prerequisites / notice Announced to students of the of the MAS / CAS at the beginning of the term.

166-0203-00L Energy Carrier for the Mobility of the Future ■

Abstract
The module includes the supply of the road mobility of the future with renewable energy. The generation, transport, processing, transfer of energy to the vehicles (refueling, charging) and the energetic evaluation are presented. Electricity, hydrogen, biogenic and synthetic fuels are considered.

Objective
The aim of the module is a detailed energetic and technical understanding of the supply of road vehicles with renewable energy. Graduates know the primary energy production as well as the end energy processing of the different energy carrier concepts. In addition, they know the legal CO2 requirements for vehicle registration and are able to qualitatively assess the impact on the Swiss energy system.

Content
- The energy system of the future; biogenic and electric renewable primary energy
- End energy processing
- Transfer from the energy system to mobility and influences on the overall energy system

Lecture notes Distributed at start of module
**Major in New Business Models**

*The Major in "New Business Models" takes place only in Spring Semester*

- Start of the next course: Spring Semester 2023
- Course duration: Six months part time
- Periodicity: yearly

**Major in Transport Engineering**

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<td>149-0001-00L</td>
<td>Transport Planning - Theory and Models</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>K. W. Axhausen</td>
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<td>Only for CAS in Transport Engineering and MAS in Future Transport Systems</td>
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<tr>
<td>149-0002-00L</td>
<td>Traffic Engineering</td>
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**Master’s Thesis**

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<th>Number</th>
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<tr>
<td>166-0490-00L</td>
<td>Master’s Thesis</td>
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<td>15</td>
<td>27D</td>
<td>M. A. Streicher-Porte</td>
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**MAS in Future Transport Systems - Key for Type**

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<th>Z</th>
<th>Dr</th>
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<td>Compulsory</td>
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<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
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**Key for Hours**

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<tr>
<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
<td>European Credit Transfer and Accumulation System</td>
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<td>practical/laboratory course</td>
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<td>revision course / private study</td>
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Special students and auditors need special permission from the lecturers.
MAS in Spatial Planning
Four-semester, part-time MAS programme.

Start of the next course: Autumn Semester 2023

Lectures and Seminars

<table>
<thead>
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<tr>
<td>115-0510-00L</td>
<td>Lecture Week 10: Spatial Development</td>
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<td>2</td>
<td>1G</td>
<td>M. Nollert, J. Van Wezemael</td>
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<td>a basis also for the work in the</td>
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<td>115-0511-00L</td>
<td>Lecture Week 11: Urban Planning and Urban</td>
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<td>1G</td>
<td>S. Kretz, to be announced</td>
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<td>and urban planning focuses on a</td>
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<td>urban design challenges and an</td>
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<tr>
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<td>A. Voigt</td>
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<td>1G</td>
<td>R. Nebel, A. Rupf</td>
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<td>paper using the example of the DAS</td>
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<td>2</td>
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<td>Introduction to international</td>
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<td>Exploring various scales and their</td>
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<td>interconnectedness as well as flows</td>
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<td>and practices that bridge different</td>
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<td>competitions as a tool to navigate</td>
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<td>different planning realities,</td>
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<td>terrains and transformations.</td>
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<td>Team work on an ongoing case.</td>
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<td>Learning from different spatial</td>
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<td>and improving the capacity to</td>
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<td>understand and bring solutions to</td>
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<td>115-0702-02L</td>
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<td>1G</td>
<td>J. Van Wezemael, A. Rupf</td>
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<td>consolidation of the bases for</td>
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<td>education program, the developing</td>
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<td>of an overview on the second study</td>
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<td>project and reviewing the basic</td>
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<td>teamwork gathered in the first year,</td>
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<td>adapting it if necessary in the</td>
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Projects and Individual Work

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<td>Study Project 2 (Part 1)</td>
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<td>M. Nollert, F. Argast, O. Hagen, R. Klostermann, A. Nälf-Clasen, J. Van</td>
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<td>Only for MAS in Spatial</td>
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<td>Abstract</td>
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<td>Conceiving strategies for sustainable spatial development in the Geneva</td>
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<td>Lake-Fribourg-Bern region: spatial planning analysis of the situation</td>
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<td>(goals and problems, potentials and risks, strengths and weaknesses);</td>
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<td>concept design (goals and measures); program development (objective and</td>
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<td>temporal priorities); preparation for implementation (instruments and</td>
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<td>proceedings); independent team work.</td>
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<td>Objective</td>
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<td>Detecting and assessing crucial issues of spatial development and</td>
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<td>identifying requested planning action. Concentrate resources, evaluate</td>
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<td>different solution concepts and demonstrate their feasibility</td>
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<td>exemplary. Recognizing possibilities and limits of formal and informal</td>
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<td>planning and apply them in practice. Efficient interdisciplinary team work,</td>
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<td>making optimal use of individual knowledge and skills of team members.</td>
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MAS in Spatial Planning - Key for Type

<table>
<thead>
<tr>
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<th>Courses outside the curriculum</th>
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<td>W</td>
<td>Eligible for credits</td>
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<td>E-</td>
<td>Recommended, not eligible for</td>
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<td>credits</td>
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<td>Suitable for doctorate</td>
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**Key for Hours**

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<tr>
<td>V</td>
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<td>exercise</td>
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<td>colloquium</td>
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<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Core Courses

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<tr>
<th>Number</th>
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<tr>
<td>118-0101-00L</td>
<td>Water Resources Seminars</td>
<td>O</td>
<td>3</td>
<td>3S</td>
<td>D. Molnar, A. Costa</td>
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</table>

**Abstract**

The Seminar Series features invited experts from a wide range of disciplines who present their experiences working with water related topics in Swiss and international settings. The students are exposed to many different perspectives and are asked to apply the information they learn to specific case studies.

**Objective**

The Seminar Series provides students with background information on a wide range of topics related to water resources. Invited experts challenge the students to consider water resources and water resource management in new ways, using tools that have been successfully implemented in real case scenarios. The seminars include theory, case studies, and interactive discussions with the experts.

**Content**

The Seminar Series is aimed at offering students the opportunity to learn about water resources in a multi-disciplinary fashion, with a focus on Swiss and international examples. Selected topics include: Water & Climate Change, Water & Sanitation, Water Management in Central Asia, Water & Agriculture, Nature Based Solutions, Water Hazards (floods), Water & Business, and Water Stewardship. For additional details see the course website https://mas-swr.ethz.ch/curriculum/courses/core-courses/water-resources-seminars.html.

**Prerequisites / notice**

For further information, contact Dr. Darcy Molnar (darcy.molnar@ifu.baug.ethz.ch)

| Number       | Nature-Based Solutions and Blue Green Infrastructure | O    | 3    | 2G    | D. Molnar, P. M. Bach          |

**Abstract**

Nature-based solutions (NbS) are effective means of addressing global societal challenges such as the need for water and food security, disaster risk reduction, and adaptation to climate change. Students are exposed to a variety of topics around NbS and Blue Green Infrastructure, gaining insight into how societies can incorporate ecosystem-based solutions to become more resilient and sustainable.

**Objective**

Nature-based solutions leverage water resource management to not only provide basic water servicing needs, but also a range of ecosystem services for the benefits of humans and the environment. At the urban and peri-urban level, multi-functional Blue Green Infrastructure solutions (inspired by nature-based concepts) are being developed that involve a broad range of stakeholders and a complex policy environment.

The course will provide students with an overarching picture of how Nature-based solutions and Blue Green infrastructure are being used to make societies and cities greener, more resilient, climate-adaptive, more liveable, sustainable, and especially, how water resources management is being leveraged to accomplish this. Students will gain insight into suitable tools and approaches to navigating interactions between relevant stakeholders, hands-on experience through a scenario-based real-world project, a field visit to an urban case study, as well as insights from leading public and private sector experts in Nature-based Solutions and Blue Green Infrastructure.

**Content**

The course is designed to expose students to different ways of thinking across multiple disciplines, but with a focus on how, as future professionals, they can facilitate and provide tangible solutions that are multi-functional and accepted by a wide array of decision-makers. Selected topics include: (1) understanding how Nature-based solutions and Blue Green Infrastructure can be used to address global societal challenges, (2) understanding the need for different levels of planning in order to design effective solutions and policies that will ensure sustainable development, (3) identifying and understanding the function of suitable infrastructure to complement existing systems, (4) support tools and quantitative approaches for evidence-based performance evaluation, and (5) planning and decision-making around Nature-based solutions.

**Lecture notes**

There is no textbook. Learning materials consist of lectures, videos, and references provided by the instructors on the course Moodle page.

**Literature**

Literature consists of research papers and journal articles provided by the instructors on the course Moodle page.

**Prerequisites / notice**

Bachelor or Master studies in environmental engineering, environmental sciences, or architecture/urban planning.

For further information, contact the MAS coordinator, Darcy Molnar (darcy.molnar@ifu.baug.ethz.ch)

## Foundation Courses

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<th>Number</th>
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<tr>
<td>118-0114-00L</td>
<td>Water Resources Seminars</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>D. Molnar, P. M. Bach</td>
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**Abstract**

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

**Objective**

The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

**Content**

The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

**Lecture notes**

There is no script.

**Literature**

The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

**Prerequisites / notice**

Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

## Prerequisites / notice

For further information, please visit: http://www.mas-swr.ethz.ch/
### Content
The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated. All methods discussed are applied pratically. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

### Literature
Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

### 102-0227-00L

<table>
<thead>
<tr>
<th>Systems Analysis and Mathematical Modeling in Urban Water Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of participants limited to 50.</strong></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
</tr>
<tr>
<td>- Introduction into modeling and simulation</td>
</tr>
<tr>
<td>- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)</td>
</tr>
<tr>
<td>- Ideal reactors</td>
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<tr>
<td>- Hydraulic residence time distribution and modeling of real reactors</td>
</tr>
<tr>
<td>- Dynamic behavior of reactor systems</td>
</tr>
<tr>
<td>- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation</td>
</tr>
<tr>
<td>- Introduction to process control (PID controller, fuzzy control)</td>
</tr>
<tr>
<td><strong>Content</strong></td>
</tr>
<tr>
<td><strong>Literature</strong></td>
</tr>
</tbody>
</table>

### Prerequisites / notice
Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
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<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Communication</th>
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<tbody>
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<td>Cooperation and Teamwork</td>
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<td></td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Negotiation</td>
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<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<tr>
<td></td>
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<td>Self-direction and Self-management</td>
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### 102-0617-00L Basics and Principles of Radar Remote Sensing for Environmental Applications

**W 3 credits 2G I. Hajnsek**

**Abstract**
The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

**Objective**
At the end of the course the student has the understanding of
1. SAR basics and principles,
2. SAR polarimetry,
3. SAR interferometry and
4. environmental parameter estimation from multi-parametric SAR data.

**Content**
The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:
1. Introduction into SAR basics and principles
2. Introduction into electromagnetic wave theory
3. Introduction into scattering theory and decomposition techniques
4. Introduction into SAR interferometry
5. Introduction into polarimetric SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

**Lecture notes**
Handouts for each topic will be provided.

**Literature**
First readings for the course:
Complete literature listing will be provided during the course.

### 102-0215-00L Urban Water Management II

**W 4 credits 2G M. Maurer, P. Staufer**

**Abstract**

**Objective**
Consolidation of the basic procedures for design and operation of technical networks in water engineering.

**Content**
Demand Side Management versus Supply Side Management
Optimierung von Wasserverteilnetzen
Kalkausfällung, Korrosion von Leitungen
Hygiene in Verteilnetzen
Siedlungshydrologie: Niederschlag, Abflussbildung
Instationäre Strömungen in Kanalisationen
Stofftransport in der Kanalisation
Einleitbedingungen bei Regenwetter
Versickerung von Regenwasser
Generelle Entwässerungsplanung (GEP)

**Lecture notes**
Written material will be available digital.

**Prerequisites / notice**
Prerequisite: Introduction to Urban Water Management
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology.

Method-specific Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Self-presentation and Social Influence

Personal Competencies
- Sensitivity to Diversity
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Theoretical introduction to the architecture, modules, spatial data types and spatial data handling functions of geographic information systems.

The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

Lecture notes
- Documentation and supporting material:
  - slides used during the lecture
  - exercise sets and solutions
  - R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

Literature
- For complementary reading:

Prerequisites
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

Number of participants limited to 60.

For complementary reading:

Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

Number of participants limited to 60.

Introduction to the architecture and data processing capabilities of geographic information systems (GIS). Practical application of spatial data modeling and geoprocessing functions to a selected project from the earth sciences.

Knowledge of the basic architecture and spatial data handling capabilities of geographic information systems.

Theoretical introduction to the architecture, modules, spatial data types and spatial data handling functions of geographic information systems (GIS). Application of data modeling principles and geoprocessing capabilities using ArcGIS: Data design and modeling, data acquisition, data integration, spatial analysis of vector and raster data, particular functions for digital terrain modeling and hydrology, map generation and 3D-visualization.

Introduction to Geographic Information Systems, Tutorial: Introduction to ArcGIS Pro


Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

**Prerequisites / notice**

**Subject-specific Competencies**
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Method-specific Competencies**
- Communication
- Cooperation and Teamwork
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Elective Courses**

Ejectives: 6 credits has to be achieved.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-6215-00L</td>
<td>Using R for Data Analysis and Graphics (Part I)</td>
<td>W</td>
<td>1.5</td>
<td>1G</td>
<td>M. Mächler</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course provides the first part an introduction to the statistical software R (<a href="https://www.r-project.org/">https://www.r-project.org/</a>) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.</td>
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<tr>
<td>Objective</td>
<td>The students will be able to use the software R for simple data analysis and graphics. The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.</td>
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</table>
| Content       | Part I of the course covers the following topics: 
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots. 

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

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<tbody>
<tr>
<td>Prerequisites / notice</td>
<td>The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should &quot;automatically&quot; make you a student participant of the Moodle course of this lecture, which is at <a href="https://moodle-app2.let.ethz.ch/course/view.php?id=15518">https://moodle-app2.let.ethz.ch/course/view.php?id=15518</a></td>
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<table>
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<tr>
<th>651-4077-00L</th>
<th>Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)</th>
<th>W</th>
<th>3</th>
<th>1V</th>
<th>University lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.</td>
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<tr>
<td>Objective</td>
<td>Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.</td>
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<tr>
<td>Content</td>
<td>Erosion and sedimentation by glaciers as a function of topography, englacial temperature, sediment balance, sliding and melt water runoff. Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).</td>
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<tr>
<td>Lecture notes</td>
<td>Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.</td>
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<tr>
<td>Literature</td>
<td>references in skript</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes</td>
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</tbody>
</table>
A. Carminati

The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a

Physics of Glaciers

This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It

J. Ghazoul

No Script

Students are able to

Will be provided on Moodle

A list of relevant literature is available on Moodle

High-school mathematics and physics knowledge required.

701-1631-00L  Foundations of Ecosystem Management

Priority is given to the target groups until 26.09.2022,

Target groups

MAS ETH in Raumplanung

MAS ETH in Sustainable Water Resources

Science, Technology and Policy MSc

Environmental Sciences MSc

Agricultural Sciences MSc

Waiting list will be deleted on 30.09.2022

Abstract

This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

Objective

Students should be able to

a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.

b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

Content

Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

Lecture notes

No Script

Literature


701-0535-00L  Environmental Soil Physics/Vadose Zone Hydrology

Abstract

The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/ near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

Objective

Students are able to

- characterize porous media at different scales

- parameterize structural, flow and transport properties of partially-saturated porous media

- quantify driving forces and resulting fluxes of water, solute, and heat in soils

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1502 of 2345
Content

Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid, liquid and gaseous phases; soil water content; soil texture; particle size distributions;

Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure

Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab

Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, and capillary rise); units and calculations and measurement of equilibrium soil water potential components

Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab

Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)

Week 7: Unsaturated water flow in soils - unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8: Numerical solution of Richards equation – using Hydrus1D for simulation of unsaturated flow; choosing class project

Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow

Week 10: Root water uptake and transpiration

Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 12: Summary of lectures; solution of old exam

Week 13: Written semester-end exam

Week 14: Short presentations of Hydrus class projects; discussion of written exam

Supplemental textbook (not mandatory) -Introduction to Environmental Soil Physics, by: D. Hillel

<table>
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<th>Credits</th>
<th>Subfields</th>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>5</td>
<td>W</td>
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<tr>
<td>Literature</td>
<td></td>
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<tr>
<td>Abstract</td>
<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<tr>
<td>Objective</td>
<td>The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.</td>
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<tr>
<td>Content</td>
<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.</td>
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<td>Taught</td>
<td>The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.</td>
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</thead>
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<tr>
<td>701-1551-00L</td>
<td>Does not take place this semester.</td>
<td>3</td>
<td>P. Krüttli, D. Nef</td>
</tr>
</tbody>
</table>
Students will have a broad understanding of the hydrological, biogeochemical, and geomorphological functioning of mountain catchments.

The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, Powerpoint slides will be made available

Assessment: not assessed

M. Mächler

1G

Creative Thinking

The students can understand the role of land processes and associated feedbacks in the climate system.

The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

Lecture notes

Handouts are provided

Literature

Selected scientific articles and book-chapters

Prerequisites / notice

Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L)

Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed

Personal Competencies

- Creative Thinking: assessed
- Critical Thinking: assessed

701-1644-00L Mountain Forest Hydrology

5 credits 3G J. W. Kirchner

Abstract

This course presents a process-based view of the hydrology, biogeochemistry, and geomorphology of mountain streams. Students learn how to integrate process knowledge, data, and models to understand how landscapes regulate the fluxes of water, sediment, nutrients, and pollutants in streams, and to anticipate how streams will respond to changes in land use, atmospheric deposition, and climate.

Objective

Students will have a broad understanding of the hydrological, biogeochemical, and geomorphological functioning of mountain catchments. They will practice using data and models to frame and test hypotheses about connections between streams and landscapes.

Content

Streams are integrated monitors of the health and functioning of their surrounding landscapes. Streams integrate the fluxes of water, solutes, and sediment from their contributing catchment area; thus they reflect the spatially integrated hydrological, ecophysiological, biogeochemical, and geomorphological processes in the surrounding landscape. At a practical level, there is a significant public interest in managing forested upland landscapes to provide a reliable supply of high-quality surface water and to minimize the risk of catastrophic flooding and debris flows, but the scientific background for such management advice is still evolving.

Using a combination of lectures, field exercises, and data analysis, we explore the processes controlling the delivery of water, solutes, and sediment to streams, and how those processes are affected by changes in land cover, land use, and climate. We review the connections between process understanding and predictive modeling in these complex environmental systems. How well can we understand the processes controlling watershed-scale phenomena, and what uncertainties are unavoidable? What are the relative advantages of top-down versus bottom-up approaches? How much can "black box" analyses reveal about what is happening inside the black box? Conversely, can small-scale, micro-mechanistic approaches be successfully "scaled up" to predict whole-watershed behavior? Practical problems to be considered include the effects of land use, atmospheric deposition, and climate on streamflow, water quality, and sediment dynamics, illustrated with data from experimental watersheds in North America, Scandinavia, and Europe.

Using R for Data Analysis and Graphics (Part II)

W 1.5 credits 1G M. Mächler

Abstract

The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

Objective

The students will be able to use the software R efficiently for data analysis, graphics and simple programming.
Content

The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options
- Extending basic R: packages

Lecture notes

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Prerequisites / notice

An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Basic knowledge of R equivalent to "Using R .. (part 1)" (= 401-6215-00L) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should *automatically* make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15522

▶ Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>118-0121-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>24 credits</td>
<td>51D</td>
<td>Lecturers</td>
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</table>

**Abstract**

Students propose relevant research topics from their home countries or from ongoing research projects at ETH, around which individual study programmes are devised, and on which they write their thesis. The Master thesis is supervised by scientific staff at ETH and collaborating institutions, and is based on the student's academic or professional experience.

**Objective**

The Master Thesis research takes place throughout the duration of the MAS Programme (12 months), complimented by Master level coursework and seminars focusing on water resources and sustainability. Students become familiar with new research techniques and receive guidance from experts. The topic of the research should address a current water resources challenge in the student's home country or in Switzerland, and is aimed at enhancing collaboration between academics and professionals in Switzerland and abroad.

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**MAS in Sustainable Water Resources - Key for Type**

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

**Key for Hours**

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium | | |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Technologies substantially affect the way we live and how our societies function. Technological change, i.e. the innovation and diffusion of new technologies, is a fundamental driver of economic growth but can also have detrimental side effects. This module introduces methods to assess technology-related policy alternatives and to analyze how policies affect technological changes and society.

Participants understand (1) how to perform policy analyses related to technology; (2) a policy problem and the rationale for policy intervention; (3) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (4) how to assess policy alternatives, using various ex ante policy analysis methods; and (5) how to communicate the results of the analysis. Evaluation of Policy Outcomes: Participants understand (1) when and why policy outcomes can be evaluated based on observational or experimental methods, (2) basic methods for evaluating policy outcomes (e.g. causal inference methods and field experiments), (3) how to apply concepts and methods of policy outcome evaluation to specific cases of interest. Big Data Approaches to Policy Analysis: Participants understand (1) why “big data” techniques for making policy-relevant assessments and predictions are useful, and under what conditions, (2) key techniques in this area, such as procuring big datasets; pre-processing and dimension reduction of massive datasets for tractable computation; machine learning for predicting outcomes; interpreting machine learning model predictions to understand what is going on inside the black box; data visualization including interactive web apps. Literature Course materials can be found on Moodle.

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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**Course materials** can be found on Moodle.
**MAS in Technology and Public Policy - Key for Type**

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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>exercise</td>
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<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Urban and Territorial Design

The MAS in Urban and Territorial Design requires one year of full-time postgraduate study for a 60 ECTS joint degree, the "MAS ETH EPF UTD". It is taught in English and held at the two Swiss schools, EPFL (Autumn) and ETH Zurich (Spring).

### Design Studio and Postproduction

<table>
<thead>
<tr>
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<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>078-0100-00L</td>
<td>Core Design and Research Studio I (EPFL)</td>
<td>O</td>
<td>16</td>
<td>17G</td>
<td>external organisers</td>
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<tr>
<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
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<tr>
<td>Abstract</td>
<td>Lecturers: P. Viganò with C. Fivet, L. Rossi and guests. The Core Studio will reflect on the “transition”, assuming its multiple dimensions (ecological, social and economic) and developing transcalar design operations in concrete territories. The territory of Greater Geneva will be the test-bed for radical design explorations of possible futures.</td>
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<tr>
<td>Objective</td>
<td>Different urban conditions will be considered in order to understand, read and manage the thick complexity of the contemporary habitat where densities, distances, relations and practices shape heterogeneous spaces and ecologies. Conceived as a place of interaction among disciplines, the studio also constitutes the main tool to develop interdisciplinarity within the design practice.</td>
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<tr>
<td>Content</td>
<td>A series of lectures will deal with ecology; the organism and its environment; population and community ecology; and biodiversity. Others lectures on design as knowledge production and representation—GIS, video and photography—will be embedded within the activities of the studio. Fieldwork is integral to the design studio.</td>
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<tr>
<th>Number</th>
<th>Postproduction I (EPFL)</th>
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<th>external organisers</th>
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<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
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<tr>
<td>Abstract</td>
<td>Lecturer: P. Viganò. The last period of the semester in January will consist of a post-production session, related to the results at EPFL. It mainly concerns the products of the Core Studio, but will also be implemented by the associated teaching.</td>
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<tr>
<td>Objective</td>
<td>All research and design materials produced during the studio, courses and sessions (e.g. texts, maps, drawings, etc.) will be evaluated, edited and curated in a “Semester Report” by the core teaching team and a graphic designer. At the end of the “Report” will be available online.</td>
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### Interdisciplinary Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>078-0200-00L</td>
<td>City, Habitat and Mobility (EPFL)</td>
<td>O</td>
<td>3</td>
<td>3G</td>
<td>external organisers</td>
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<tr>
<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
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<tr>
<td>Abstract</td>
<td>Lecturers: V. Kaufmann with L. Pattaroni. The course aims to understand the political and social conditions of urban lifestyles and mobilities patterns in order to explore the levers of action available to professionals to support the critical emergence of renewed urban models.</td>
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<tr>
<td>Objective</td>
<td>Taking the form of a course - seminar, the proposed teaching aims to show the interest of methodologies from the social sciences of the city to develop critical urban and territorial design. Planned to last 12 weeks, it proposes to take up each week a theme related to the relation between city, habitat and mobility.</td>
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<tr>
<td>Content</td>
<td>Each session is organized in two parts: (1) a presentation by one of the students of an article on the week’s theme, followed by a discussion, and (2) a presentation by the teaching team to identify the knowledge and debates of social sciences related to urban and territorial design issues. Two sessions will be devoted to field visits.</td>
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<thead>
<tr>
<th>Number</th>
<th>Building Design in the Circular Economy (EPFL)</th>
<th>O</th>
<th>3</th>
<th>3G</th>
<th>external organisers</th>
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<tbody>
<tr>
<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
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<tr>
<td>Abstract</td>
<td>Lecturer: C. Fivet. The circular economy consists in maintaining the value of products as long as possible by extending or renewing their service life while minimizing resource depletion, waste and greenhouse gas emissions. The integration of these principles in the construction industry has many facets that often contradict each other.</td>
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<tr>
<td>Objective</td>
<td>While introducing students to the concept of the circular economy and its applications to building design, the class provides ready-to-use techniques and aims at developing a critical mindset towards their use. Following a &quot;flipped classroom&quot; methodology, the class devolves into recent literature and practice by means of adversarial open debates. Examination consists in the writing of a short personal essay on a chosen topic and its oral defence.</td>
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<thead>
<tr>
<th>Number</th>
<th>Urban Hydrology (EPFL)</th>
<th>O</th>
<th>2</th>
<th>2G</th>
<th>external organisers</th>
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<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
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<tr>
<td>Abstract</td>
<td>Lecturer: L. Rossi. This course addresses water management from a global point of view, including in particular the impacts of rain discharges on receiving environments. The qualitative aspects (risk of contamination) are considered as a priority, in parallel with the quantitative risks (floods).</td>
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<tr>
<td>Objective</td>
<td>The course aims to understand the means and issues of management and maintenance of sewerage systems, finalized to the control of impacts in receiving environments, and more generally to raise the importance of hydraulic management in the urban and territorial project.</td>
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<tr>
<td>Content</td>
<td>General introduction - Legislative aspects related to urban hydrology - Simplified design methods and technical solutions: from source control to solutions at the end of the network - Field visits</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Introduction to the Fundamentals of Natural Environment</th>
<th>W</th>
<th>1</th>
<th>2V</th>
<th>T. Gali-Izard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>This course is suitable for MSc and MAS UTD students only!</td>
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<tr>
<td>Abstract</td>
<td>This course consists of a lecture series providing some fundamental knowledge in natural environment with experts and academics from various disciplines, such as geology, climate, ecology, soil and plant sciences.</td>
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<tr>
<td>Objective</td>
<td>Participants become acquainted with relevant issues and topics about the natural environment and gain valuable insights into the interaction of all living and non-living things, climate, weather and natural resources. The active participation in discussions following presentations by invited lecturers stimulate critical thinking and allow participants to tackle relevant environmental challenges and discuss opportunities with academics and experts as well as to exchange ideas amongst the participants.</td>
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</tbody>
</table>
This course is a series of lectures by academics and experts who present their research and fundamental knowledge across the field of the environmental sciences (geology, climate, ecology, soil and plant sciences). The active participation in critical discussions following each presentation allows participants to tackle relevant challenges in the natural environment with academics and experts.

Tuesday 20.9.22, 9-11:30 Uhr, «Land-Climate Dynamics» with Dr. Jonas Schwaab, Dr. Gianluca Mussetti
Thursday 22.9.22 9-11:30 Uhr, «Introduction to Geology» with Dr. Maria Giuditta Fellin, Dr. Vincenzo Picotti
Monday 3.10.22: 14:45-18:30 Uhr «Introduction to Soils» with Dr. Ruben Kreitzschmar
Wednesday 5.10.22: 9-11:30 Uhr, «Soil Biology & Ecology» with Dr. Aline Frassard
Thursday 13.10.22, 9-13:30: «Tree Architecture & Evolution» with Dr. Guillaume Chomicki
Friday 14.10.22, 9-11:30, «Plant Systematics I» with Alessia Dr. Guggisberg
Friday 21.10.22, 9-11:30, «Disturbance Ecology» with Dr. Thomas Wohlgemuth

Lecture notes: More details about each lectures, as well as keywords and topics relevant for and discussed during the lectures are published in advance on the course web page: mscla.arch.ethz.ch

Prerequisites / notice: No previous knowledge in environmental sciences is required.

Urban Theory Sessions

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>078-0300-00L</td>
<td>Histories of Environment (EPFL)</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>external organisers</td>
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<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
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<tr>
<td>Abstract</td>
<td>Lecturers: S. Marot and guests. As a guiding principle that remains to be defined, the transition can be critically confronted with broader histories of the environment. The various and even very opposite hypotheses it contains will be differentiated and deepened in the module. In particular that of autonomy will be discuss regarding to the so-called &quot;secession&quot; scenario.</td>
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<tr>
<td>Objective</td>
<td>This session aims to understand how and to what extent environmental concerns can influence urban and territorial design. From a critical point of view, it also intends to question the notion of transition under the prism of its antecedents in ecological thinking.</td>
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<tr>
<td>078-0301-00L</td>
<td>Systemic Thinking in the Age of Transition (EPFL)</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>external organisers</td>
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<td>Only for MAS in Urban and Territorial Design</td>
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<tr>
<td>Abstract</td>
<td>Lecturers: E. Cogato-Lanza, A. Pagani, guests. Systems thinking has regained its topicality due to the need to apprehend interdependencies that characterize our inhabited environment. The technicist approach, which had favored complexity without relating it to systems, has given way to interdisciplinary, contextual and holistic frameworks of understanding and action that lead to new prototypes.</td>
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<tr>
<td>Objective</td>
<td>The seminar intends to draw up a cartography of the most current theoretical references and strategic experiments of systemic thinking in the field of the territorial project. The two envisaged formats will associate the series of conferences, bringing together protagonists and researchers, with more strictly seminal sessions with a comparative, inventory or bibliographical tone.</td>
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<tr>
<td>Content</td>
<td>The seminar is structured in four modules: Polemics; Concepts; Representations; Projects.</td>
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MAS in Urban and Territorial Design - Key for Type

<table>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Modules

<table>
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<tr>
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<tr>
<td>868-0001-00L</td>
<td>Module 1: Mediation in Context</td>
<td>O</td>
<td>10 credits</td>
<td>9G</td>
<td>A. Wenger, L.-E. Cederman</td>
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<td><strong>Does not take place this semester.</strong></td>
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<td><strong>Only for MAS Mediation in Peace Processes.</strong></td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This module defines and contextualises peace mediation in relation to other conflict resolution approaches. The module focuses heavily on conflict analysis, introducing the students to the latest knowledge about conflict typologies, trends, and causes in addition to providing them with various opportunities to practice conflict analysis using diverse methods.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td>868-0004-00L</td>
<td>Module 4: Mediation Process Design</td>
<td>O</td>
<td>10 credits</td>
<td>9G</td>
<td>A. Wenger</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Mediators help the parties reach a peace agreement by designing and structuring the process. This module covers the basic elements of process design and how they differ. Important to process design is the reflection on theory and practice in sequencing the content to be examined. The module then explores the implications and challenges facing the implementation of peace agreements for mediators.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td></td>
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</table>

### MAS Mediation in Peace Processes - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

<table>
<thead>
<tr>
<th>ECTS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>European Credit Transfer and Accumulation System</td>
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</tbody>
</table>

Special students and auditors need special permission from the lecturers.
Upon completion of this course, students will be able to recognize linear structures, and to solve corresponding problems in theory and in applications. The course offers an introduction into the theory with many examples from mechanics, physics and other areas which are basic to engineering. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications. The new notions are practised in the accompanying exercise classes. The course will be continued as Linear algebra II.

Active participation in the exercises is part of this course. It is expected, that students submit 3/4 of all exercises for control.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0321-00L</td>
<td>Engineering Design and Material Selection</td>
<td>O</td>
<td>4 credits</td>
<td>4G</td>
<td>K. Shea</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>This course provides an introduction to engineering design. Through hands-on, practice-oriented exercises, students experience the fundamentals of design concept generation and selecting materials. They create 3D models in CAD for their own customized design and fabricate them using 3D printing. Three case studies in healthcare, mobility and sustainable materials will be explored.</td>
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<td><strong>Objective</strong></td>
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<td>The lecture and exercises teach the fundamentals of engineering design, drawing and CAD as well as additive manufacturing and material selection. After taking the course, students will be able to tackle simple design tasks, generate and evaluate concepts, accurately create technical drawings of parts and assemblies as well as read them. Students will also be able to create models of parts and assemblies in a 3D, feature-based CAD system. They will understand the links between engineering design and material selection, with a particular focus on sustainable materials, as well as additive manufacturing.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Introduction to Engineering Design</td>
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<td></td>
<td>• design requirements</td>
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<td></td>
<td>• concept generation and selection</td>
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<td></td>
<td>• prototyping</td>
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<tr>
<td></td>
<td>Design Representations</td>
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<td></td>
<td>• Technical Drawing:</td>
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<tr>
<td></td>
<td>o projections, views and cuts</td>
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<td>o dimensioning</td>
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<td>o assemblies</td>
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<td>• CAD:</td>
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<td></td>
<td>o CAD modeling operations</td>
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<td>o parametric design and feature-based modeling</td>
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<td>o assemblies</td>
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<td>o creating 2D drawings from 3D part models</td>
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<td>Fabrication and Additive manufacturing</td>
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<td>Material Selection</td>
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<td>• materials and their properties, with special emphasis on sustainable materials</td>
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<td></td>
<td>• basic mechanics</td>
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<td>• material selection processes</td>
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<td>• testing material properties</td>
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<td>Three case studies in healthcare, mobility and sustainable materials</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<td>Lecture slides and exercise handouts are available on the course Moodle website: <a href="https://moodle-app2.let.ethz.ch/course/view.php?id=17403">https://moodle-app2.let.ethz.ch/course/view.php?id=17403</a></td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td>All literature will be given on the Moodle website: <a href="https://moodle-app2.let.ethz.ch/course/view.php?id=17403">https://moodle-app2.let.ethz.ch/course/view.php?id=17403</a></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>This course is given as a lecture (1h/week) and an exercise (3h/week). Students are split into working groups for the exercises with a maximum of 20 students per group.</td>
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**Bachelor Studies (Programme Regulations 2010)**

**3. Semester: Compulsory Courses**

**Examination Block 1**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0363-10L</td>
<td>Analysis III</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>A. Iozzi</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.</td>
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</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1512 of 2345
Chapter 1: Laplace Transforms
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Chapter 2: Fourier Series, Integrals and Transforms
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Chapter 3: Partial Differential Equations
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Lecture notes
Lecture notes by Prof. Dr. Alessandra Iozzi:
https://polybox.ethz.ch/index.php/s/D3K0TayQXvfpCAA

Literature

For reference/complement of the Analysis I/II courses:
Christian Blatter: Ingenieur-Analysis
https://people.math.ethz.ch/~blatter/dlp.html

Module: Dynamics
O 6 credits 4V+2U D. Kochmann

Abstract
Dynamics of particles, rigid bodies and deformable bodies: Motion of a single particle, motion of systems of particles, 2D and 3D motion of rigid bodies, vibrations, waves

Objective
This course provides Bachelor students of mechanical and civil engineering with fundamental knowledge of the kinematics and dynamics of mechanical systems. By studying the motion of a single particle, systems of particles, of rigid bodies and of deformable bodies, we introduce essential concepts such as kinematics, kinetics, work and energy, equations of motion, and forces and torques. Further topics include the stability of equilibria and vibrations as well as an introduction to the dynamics of deformable bodies and waves in elastic rods.
Throughout the course, the basic principles and application-oriented examples presented in the lectures and weekly exercise sessions help students acquire a proficient background in engineering dynamics, learn and embrace problem-solving techniques for dynamical engineering problems, gain cross-disciplinary expertise (by linking concepts from, among others, mechanics, mathematics, and physics), and prepare students for advanced courses and work on engineering applications.

Content
1. Motion of a single particle: kinematics (trajectory, velocity, acceleration), forces and torques, constraints, active and reaction forces, balance of linear and angular momentum, work-energy balance, conservative systems, equations of motion.
2. Motion of systems of particles: internal and external forces, balance of linear and angular momentum, work-energy balance, rigid systems of particles, particle collisions, mass accretion/loss.
3. Motion of rigid bodies in 2D and 3D: kinematics (angular velocity, velocity and acceleration transfer, instantaneous center and axis of rotation), balance of linear and angular momentum, work-energy balance, angular momentum transport, inertial vs. moving reference frames, apparent forces, Euler equations.
5. Introduction to waves and vibrations in deformable elastic bodies: local form of linear momentum balance, waves and vibrations in slender elastic rods.

Lecture notes
Lecture notes (a scriptum) will be available on Moodle. Students are strongly encouraged to take their own notes during class.

Literature
A complete set of lecture notes (a scriptum) is available on Moodle. Further reading materials are suggested but not required for this class.

Prerequisites / notice
All course materials (including lecture notes, exercise problems, etc.) are available on Moodle.
151-0303-00L  **Dimensioning I**

**O** 3 credits  3G  D. Mohr, B. Berisha, E. Mazza

**Abstract**
Introduction to Dimensioning of components and machine parts. Basic structural theories are introduced and a short introduction to finite elements is given. Further, elements from fracture mechanics, plasticity and stability of structures are presented.

**Objective**
The goal of the lecture is to build on and extend the theories from Mechanics 2. Students learn how to implement adequate models for practical dimensioning problems in mechanical engineering and how to solve and critically interpret these models.

**Content**
- Basic problem of continuum mechanics
- Structural theories
- Introduction to finite element methods
- Strength of materials
- Fatigue
- Stability of structures

**Lecture notes**
Will be announced during the first lecture.

**Literature**
Will be announced during the first lecture.

151-0051-00L  **Thermodynamics I**

**O** 4 credits  2V+2U  A. Bardow, C. Müller

**Abstract**
Introduction to the fundamentals of technical thermodynamics.

**Objective**
Introduction to the fundamentals of technical thermodynamics.

**Content**
1. Konzepte und Definitionen
2. Der erste Hauptsatz, der Begriff der Energie und Anwendungen für geschlossene Systeme
3. Eigenschaften reiner kompressibler Substanzen, quasistatische Zustandsänderungen
4. Elemente der kinetischen Gastheorie
5. Der erste Hauptsatz in offenen Systemen - Energieanalyse in einem Kontrollvolumen
6. Der zweite Hauptsatz - Der Begriff der Entropie
7. Nutzbarkeit der Energie - Exergie
8. Thermodynamische Beziehungen für einfache, kompressible Substanzen.

**Lecture notes**
available

**Literature**


151-0591-00L  **Control Systems I**

**O** 4 credits  2V+2U  E. Frazzoli

**Note:** The previous course title in German until HS21 “Regelungstechnik”

**Abstract**
Analysis and controller synthesis for linear time invariant systems with one input and one output signal (SISO); transition matrix; stability; controllability; observability; Laplace transform; transfer functions; transient and steady state responses. PID control; dynamic compensators; Nyquist theorem.

**Objective**
Identify the role and importance of control systems in everyday life. Obtain models of single-input single-output (SISO) linear time invariant (LTI) dynamical systems. Linearization of nonlinear models. Interpret stability, observability and controllability of linear systems. Describe and associate building blocks of linear systems in time and frequency domain with equations and graphical representations (Bode plot, Nyquist plot, root locus). Design feedback controllers to meet stability and performance requirements for SISO LTI systems. Explain differences between expected and actual control results. Notions of robustness and other nuisances such as discrete time implementation.

**Content**

**Lecture notes**
Lecture slides and additional material will be posted online.
There is no required textbook.

A nice introductory book on feedback control, available online for free, is:

Feedback Systems: An Introduction for Scientists and Engineers
Karl J. Astrom and Richard M. Murray

The book can be downloaded at https://fbswiki.org/wiki/index.php/Main_Page

Basic knowledge of (complex) analysis and linear algebra.

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0033-10L</td>
<td>Physics I</td>
<td>O</td>
<td>6 credits</td>
<td>4V+2U</td>
<td>L. Degiorgi</td>
</tr>
</tbody>
</table>

Abstract
This is a two-semester course introducing students into the foundations of Modern Physics. Topics include electricity and magnetism, light, waves, quantum physics, solid state physics, and semiconductors. Selected topics with important applications in industry will also be considered.

Objective
The lecture is intended to promote critical, scientific thinking. Key concepts of Physics will be acquired, with a focus on technically relevant applications. At the end of the two semesters, students will have a good overview over the topics of classical and modern Physics.

Content
Electric and magnetic fields, current, magnetism, Maxwell's equations, oscillations, waves.

Lecture notes
Notes from lectures will be available (in German).

Literature
Hans J. Paus, Physik in Experimenten und Beispielen, Carl Hanser Verlag München Wien (textbook for the lecture), ca. 50 Euro.

alternative E-Book:

3. Semester: Engineering Tools

The Engineering Tools courses are for MAVT Bachelor's degree students only.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0021-00L</td>
<td>Engineering Tool: Introduction to MATLAB</td>
<td>W+</td>
<td>0.4 credits</td>
<td>1K</td>
<td>B. Berisha</td>
</tr>
</tbody>
</table>

Abstract
Introduction to MATLAB; vectors and matrices; graphics in MATLAB; calculus, differential equations; programming with MATLAB; data analysis and statistics; interpolation and polynomials. Exercises with solutions: using MATLAB commands, technical applications.
Objective
Introduction to numerical calculations with MATLAB.

Content
Introduction to MATLAB; vectors and matrices; graphics in MATLAB; calculus, differential equations; programming with MATLAB; data analysis and statistics; interpolation and polynomials. Exercises with solutions: using MATLAB commands, technical applications.

Lecture notes
Course material: https://moodle-app2.let.ethz.ch/course/view.php?id=15113

Prerequisites / notice
Der Kurs findet in einem Hörsaal statt und es stehen keine Rechner zur Verfügung. Es wird empfohlen, dass pro zwei Studierenden mindestens ein Laptop mit installiertem Matlab mitgebracht wird.

Installation Matlab:
- es funktionieren alle Versionen
- netzunabhängige Node-Lizenz (z.B. zum Download im ETH IT Shop)
- folgende Toolboxes/Features müssen installiert sein: Simulink (wird für RT1 benutzt), Curve Fitting Toolbox, Optimization Toolbox, Symbolic Toolbox, Global Optimization Toolbox

252-0863-00L Engineering Tool: Advanced Programming with C++ W+ 0.4 credits 1K F. O. Friedrich Wicker

All Engineering Tool courses are for MAVT-Bachelor students only.

Abstract
The programming model of C++ is discussed in some depth. In particular the mechanisms for efficient memory management and generic programming with C++ are covered.

Objective
Ability to implement memory-efficient data structures and efficient generic algorithms using C++.

Content
Vectors, pointers and iterators, range for, keyword auto, a class for vectors, subscript-operator, move-construction and iteration. RAII (Resource Allocation is Initialization) Principle, Templates and Generic Programming, Functions and Lambda Expressions.

Lecture notes
Detailed, bilingual slides of the lectures will be made available.

Literature

Prerequisites / notice
Lecture Series Informatik I 252-0852-00L or equivalent knowledge in programming with C++.

Course can only be taken if the programming project is executed and submitted. If no solution to the programming project is submitted, the course is considered failed (=no show=).

5. Semester: Compulsory Courses Examination Block 3

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0261-00L</td>
<td>Thermodynamics III</td>
<td>O</td>
<td>3 credits</td>
<td>2+1U</td>
<td>R. S. Abhari, A. Steinfeld</td>
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<tr>
<td></td>
<td>Technical applications of engineering thermodynamics. Extension of thermodynamical fundamentals taught in Thermodynamics I and II.</td>
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<td></td>
<td>Understand and apply thermodynamic principles and processes for use in a range of cycles used commonly in practice.</td>
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</tbody>
</table>

| 151-0103-00L | Fluid Dynamics II         | O    | 3 credits | 2+1U  | P. Jenny          |
|              | Two-dimensional irrotational (potential) flows: stream function and potential, singularity method, unsteady flow, aerodynamic concepts. |      |      |                   |                    |
|              | Vorticity dynamics: vorticity and circulation, vorticity equation, vortex theorems of Helmholtz and Kelvin. |      |      |                   |                    |
|              | Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Meyer expansion, viscous effects. |      |      |                   |                    |
|              | Concepts, phenomena and quantitative description of irrotational (potential), rotational, and one-dimensional compressible flows. |      |      |                   |                    |
|              | Two-dimensional irrotational (potential) flows: stream function and potential, complex notation, singularity method, unsteady flow, aerodynamic concepts. |      |      |                   |                    |
|              | Vorticity dynamics: vorticity and circulation, vorticity equation, vortex theorems of Helmholtz and Kelvin. |      |      |                   |                    |
|              | Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Meyer expansion, viscous effects. |      |      |                   |                    |
|              | Lecture notes are available (in German). (See also info on literature below.) |      |      |                   |                    |
| Literature  | Relevant chapters (corresponding to lecture notes) from the textbook |      |      |                   |                    |
| Prerequisites / notice | Analysis III, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas |      |      |                   |                    |

Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0573-00L</td>
<td>System Modeling</td>
<td>W</td>
<td>4 credits</td>
<td>2+1U</td>
<td>L. Guzzella</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to system modeling for control. Generic modeling approaches based on first principles, Lagrangian formalism, energy approaches and experimental data. Model parametrization and parameter estimation. Basic analysis of linear and nonlinear systems.</td>
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<tr>
<td>Objective</td>
<td>Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.</td>
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<tr>
<td>Content</td>
<td>This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>The handouts in English will be available in digital form.</td>
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</tr>
<tr>
<td>Literature</td>
<td>A list of references is included in the handouts.</td>
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<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies</td>
<td>Method-specific Competencies</td>
<td>Social Competencies</td>
<td>Personal Competencies</td>
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<tr>
<td>assessed</td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
<td></td>
</tr>
<tr>
<td>assessed</td>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>assessed</td>
<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>assessed</td>
<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>not assessed</td>
<td></td>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td>not assessed</td>
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<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<tr>
<td>not assessed</td>
<td></td>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
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<tr>
<td>not assessed</td>
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<table>
<thead>
<tr>
<th>151-0575-01L</th>
<th>Signals and Systems</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>A. Carron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.</td>
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<tr>
<td>Objective</td>
<td>Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture notes available on course website.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Control Systems I is helpful but not required.</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>151-0917-00L</th>
<th>Mass Transfer</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>S. E. Pratsinis, V. Mavrantzas, C.-J. Shih</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.</td>
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<tr>
<td>Objective</td>
<td>This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.</td>
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<tr>
<td>Content</td>
<td>Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.</td>
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</table>

<table>
<thead>
<tr>
<th>151-0973-00L</th>
<th>Introduction to Process Engineering</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>F. Donat, C. Müller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Overview of process engineering: fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.</td>
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<tr>
<td>Objective</td>
<td>We teach the fundamentals of process engineering using practical examples as well as concrete process engineering problems in the areas of process control and balancing, thermal separation processes, mechanical separation processes and reaction engineering.</td>
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<tr>
<td>Content</td>
<td>Overview of process engineering: fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times. In addition to teaching basic theoretical knowledge, the focus is on solving typical problems in various subdisciplines of process engineering.</td>
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<tr>
<td>Lecture notes</td>
<td>A script is provided (German language).</td>
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<tr>
<td>Literature</td>
<td>Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the lecture and the exercise materials are sufficient.</td>
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<table>
<thead>
<tr>
<th>151-3207-00L</th>
<th>Lightweight</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>P. Ermanni</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The elective course Lightweight includes numerical methods for the analysis of the load carrying and failure behavior of lightweight structures, as well as construction methods and design principles for lightweight design.</td>
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<tr>
<td>Objective</td>
<td>The goal of this course is to convey substantiated background for the understanding and the design and sizing of modern lightweight structures in mechanical engineering, vehicle and airplane design.</td>
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<tr>
<td>Content</td>
<td>Lightweight design</td>
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<td></td>
<td>Thin-walled beams and structures</td>
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<tr>
<td></td>
<td>Instability behavior of thin walled structures</td>
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<tr>
<td></td>
<td>Reinforced shell structures</td>
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<td></td>
<td>Load introduction in lightweight structures</td>
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<tr>
<td></td>
<td>Joining technology</td>
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<tr>
<td></td>
<td>Sandwich design</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Script, Handouts, Exercises</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>227-0076-00L</th>
<th>Electrical Engineering II</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>C. Studer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Sinusoidal signals and systems in the time and frequency domain, principle of operation and design of basic analog and digital circuits as well as analog-digital conversion.</td>
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</tbody>
</table>
Objective: The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Prerequisites / notice: The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

401-0435-00L Computational Methods for Engineering Applications

Abstract: The course gives an introduction to the numerical methods for the solution of ordinary and partial differential equations that play a central role in engineering applications. Both basic theoretical concepts and implementation techniques necessary to understand and master the methods will be addressed.

Objective: At the end of the course the students should be able to:
- Implement numerical methods for the solution of ODEs (= ordinary differential equations);
- Identify features of PDEs (= partial differential equations) based models that are relevant for the selection and performance of a numerical algorithm;
- Implement the finite difference, finite element and finite volume method for the solution of simple PDEs using C++;
- Read engineering research papers on numerical methods for ODEs or PDEs.

Content: Initial value problems for ODE: review of basic theory for ODEs, Forward and Backward Euler methods, Taylor series methods, Runge-Kutta methods, basic stability and consistency analysis, numerical solution of stiff ODEs.

Two-point boundary value problems: Green's function representation of solutions, Maximum principle, finite difference schemes, stability analysis.

Elliptic equations: Laplace's equation in one and two space dimensions, finite element methods, implementation of finite elements, error analysis.


Hyperbolic equations: Linear advection equation, method of characteristics, upwind schemes and their stability.

Lecture notes: Script will be provided.

Literature: Chapters of the following book provide supplementary reading and are not meant as course material:

(Suggested) Prerequisites: Analysis I-III (for D-MAVT), Linear Algebra, Models, Algorithms and Data: Introduction to Computing, basic familiarity with programming in C++.

401-0603-00L Stochastics (Probability and Statistics)

Abstract: The following concepts are covered: probabilities, random variables, probability distributions, joint and conditional probabilities and distributions, law of large numbers, central limit theorem, descriptive statistics, statistical inference, parameter estimation, confidence intervals, statistical tests, two-sample tests, linear regression.

Objective: Knowledge of the basic principles of probability theory and statistics.

Content: Introduction to probability theory and statistics.


Focus Project

Focus Projects in Mechatronics and Robotics

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
151-0073-10L | GyroWheeler | W | 0 | 15A | R. Siegwart

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Abstract: Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc.).

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1518 of 2345
Objective

The various objectives of the Focus Project are:
- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Content

Soft Underwater Robotic Fish for Biodiversity Surveying (SURF-eDNA)

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Abstract

Students create a biomimetic underwater system capable of the autonomous collection of information about biodiversity in aquatic ecosystems. The students learn to work in teams, structure problems, identify solutions, perform system analysis, and present. They have access to rapid prototyping facilities and the latest engineering tools.

Objective

The various objectives of the Focus Project are:
- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Content

SURF-eDNA integrates an environmental DNA (eDNA) filter, camera, and swimming autonomy into a biomimetic soft underwater robotic fish (SURF). The goal of the project is to create a biomimetic underwater system capable of the autonomous collection of information about biodiversity in aquatic ecosystems. The system has to be minimally invasive and disruptive to the ecosystem it will be deployed in, therefore it has to employ a nature-mimicking locomotion modality.

The project is run by a team of eight students in their third year of bachelor at MAVT/ITET at ETH Zürich. The team is managed by team from the Soft Robotics Lab. The target date for a successful research demonstration is end of May 2023. The project is split into three work packages: 1) design a robotic fish for underwater sampling; 2) manufacture several robotic prototypes; and 3) provide the system with Autonomy and data collection capability.

If you like to learn more about this project, please email Prof. Robert Katzschmann (rkk@ethz.ch).

Prerequisites / notice

Basics of control theory, machine design, and dynamics. Previous exposure to mechatronics or robotic systems will also be helpful.

Taught competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Leadership and Responsibility assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-direction and Self-management assessed

151-0073-30L

AirX

Does not take place this semester.

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.
Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective

The various objectives of the Focus Project are:
- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Prerequisites / notice

This Focus-Project is supervised by the following lecturers:
Siegwart, R., ASL
Haas, R., ASL
Beardsley P., Disney Research Zurich

151-0073-40L Magnetic Monkey

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

W 0 credits 15A M. Hutter

151-0073-50L MetaSuit - Sensorized and Actuated Clothing for Pose Estimation and Haptics

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

W 0 credits 15A R. Katzschmann

Autumn Semester 2022
In this focus project, students will develop the platform MetaSuit. Together with their team, they design, build, and test a wearable suit that maps the pose and movement of the human body into a virtual reality (VR) or augmented reality (AR) space. MetaSuit envisions the integration of soft artificial muscles into a full-body suit for immersive experiences. As core enabling technology will serve hydraulically amplified electrostatic actuators that are used both for proprioception and actuation in this project.

This technology fuses thin dielectric films together to deformable pouches, injects the formed pouches with dielectric oil, and coats them with flexible electrodes. Applying low currents at high voltages actuates these capacitors by having the electrodes zip together and pushing the liquid into a sub-portion of the deformable pouch. The key idea here is to read out the zipped state of these capacitive-type actuators and therefore make them sensors.

The project’s main objective is to create a soft, light, and natural feeling suit that allows users to immerse into a target environment where the user can smoothly move and interact with objects and other users. Such target environments can range from dangerous environments that have to be cleaned up to virtual meeting places that enable learning and training.

The project is led by a team of eight undergraduate researchers that are in their 3rd year of bachelor studies at ETH Zurich. Team members have a background in computer science and mechanical/electrical engineering. The supervision and management of the team is provided by the Soft Robotics Lab. The target date for a successful research demonstration is end of May 2023.

If you like to learn more about this project, please email Prof. Robert Katzschmann (rkk@ethz.ch).

**Prerequisites / notice**
Basics of control theory, machine design, and dynamics. Previous exposure to mechatronics or robotic systems will also be helpful.

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**Focus Projects in Manufacturing Science**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0075-10L</td>
<td>e-Sling Hydrogen Powertrain</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>K. Wegener</td>
</tr>
<tr>
<td></td>
<td><em>This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. Prerequisites for the focus projects: a. Basis examination successfully passed b. Block 1 and 2 successfully passed For enrollment, please contact the D-MAVT Student Administration.</em></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>The various objectives of the Focus Project are: - Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester - Team organization, work in teams, increase of interpersonal skills - Independence, initiative, independent learning of new topic contents - Problem structuring, solution identification in indistinct problem definitions, searches of information - System description and simulation - Presentation methods, writing of a document - Ability to make decisions, implementation skills - Workshop and industrial contacts - Learning and recess of special knowledge - Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)</td>
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<tr>
<td>151-0075-20L</td>
<td>Formula Student Electric</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>D. Mohr</td>
</tr>
<tr>
<td></td>
<td><em>This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. Prerequisites for the focus projects: a. Basis examination successfully passed b. Block 1 and 2 successfully passed For enrollment, please contact the D-MAVT Student Administration.</em></td>
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</table>
Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
The various objectives of the Focus Project are:
- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

151-0075-30L  eXact - Intelligent Full Electric Excavator  W  0 credits  15A  A. Kunz
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.
For MAVT BSc and ITET BSc only.
Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
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- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Focus Projects in Energy, Flows and Processes

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0076-10L</td>
<td>αCentauri</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>P. Jenny</td>
</tr>
</tbody>
</table>
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.
For MAVT BSc and ITET BSc only.
Prerequisites for the focus projects:
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For enrollment, please contact the D-MAVT Student Administration.

Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
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- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

151-0076-20L  H2Go  W  0 credits  15A  K. Wegener
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.
For MAVT BSc and ITET BSc only.
Prerequisites for the focus projects:
a. Basis examination successfully passed
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For enrollment, please contact the D-MAVT Student Administration.
Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
The various objectives of the Focus Project are:
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- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

151-0076-30L ARIS - Liquid Rocket Engine
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Focus Projects in Engineering for Health

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0077-10L</td>
<td>MRI Heart-Lung-Machine</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>M. Meboldt</td>
</tr>
</tbody>
</table>

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Abstract
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Objective
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- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

151-0077-20L SONANO - Optoacoustic Contrast Agents
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
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For enrollment, please contact the D-MAVT Student Administration.
Abstract

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Objective

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Focus Projects in Design, Mechanics and Materials

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0079-10L</td>
<td>Multidrone</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>P. Ermanni</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester. This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. For MAVT BSc and ITET BSc only. Prerequisites for the focus projects: a. Basis examination successfully passed b. Block 1 and 2 successfully passed For enrollment, please contact the D-MAVT Student Administration.</td>
<td></td>
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</tr>
<tr>
<td>151-0079-20L</td>
<td>Retex - Textile Recycling</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>P. Ermanni</td>
</tr>
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<tr>
<td>151-0079-30L</td>
<td>Swissloop - Scaling to Reality</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>D. Kochmann</td>
</tr>
<tr>
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151-0079-40L  Swissloop Tunneling ★

Does not take place this semester.
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus-Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Abstract

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Courses Eligible for Focus Projects

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<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>151-0079-99L</td>
<td>Vacuum Transport Seminar: Insights into Hyperloop Research</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>D. Kochmann</td>
</tr>
</tbody>
</table>

Abstract

The Vacuum Transport Seminar series enters its third round following the successful editions in spring and autumn semesters. It is held online via Zoom and offered internationally across a number of European Universities. The seminar was founded and is held by Swissloop and the EuroTube Foundation, and partnered by other European institutes.

Objective

Students present their work in Hyperloop research. Additionally, industry experts contribute insight talks. The seminar is open to all students, everyone is welcome to join at any of the dates.

About the seminar’s background:

Swissloop, the Hyperloop Team based at ETH Zürich, is pursuing long-term support for research and education in vacuum transport. In addition to the active team constructing and building a Hyperloop pod every year, various research projects at ETH are pursued in cooperation with EuroTube. The EuroTube Foundation accelerates the development of sustainable vacuum transportation technologies to provide publicly accessible research and testing infrastructures for universities and industry.

About Vacuum Transportation:

The demand for air transport has more than doubled in the last 20 years and is growing yearly by about 6.5%. Global demand for cargo and passenger transportation can barely meet today - let alone in a sustainable manner. Vacuum transport can replace short to medium distance flights and can significantly reduce CO2 emissions. The market of high-speed transportation is a global megatrend set to affect our lives in years to come.

| 151-0761-00L | Practice Course Product Development | W   | 1 credit | 1G | M. Meboldt, C. R. Dietzsch, C. Schorno, M. Schütz |

Abstract

This course provides comprehensive input to ongoing focus project teams in the areas of project management, communication and presentation, as well as dealing with the media, coaches and patents and safety issues.

Objective

Participants will receive tips, hints and background information from experienced tutors applicable to current projects.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1525 of 2345
Project Management
- Creating a solid project base
- Project planning and controlling
- Product validation and testing
- Problem solving cycle and decision taking transparent for others

Communication
- Communication within the team and with coaches
- Public Relations in a Nutshell
- How to acquire and manage suppliers and sponsors
- Transfer of technical drawings to suppliers
- Technical reports
- Review presentations

Handling of and guidance to
- Expectation management and dealing with conflicts
- Burnout prevention, time management, work disturbances
- Safety issues
- Issues regarding patents

Lecture notes
Lecture notes and documentation will be electronically available.

Prerequisites / notice
- for students only participating in a Focus Project in the same semester
- the exact schedule will be communicated during the course
- it is expected, that every team is visiting each lecture with typically at least 2 team members

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151-0763-00L
Practice Course to Focus Projects on CAD and CAE
Based on Siemens NX

- Max. 3 Students by one Focus Team allowed
- Course is only useful and recommended for students using CAD and CAE Tools for their duty within the project itself
- Feel free to contact us, if there are open questions: martin.schuetz@mavt.ethz.ch

Abstract
This course provides comprehensive input to ongoing Focus Projects teams in the areas of CAD and CAE mit Siemens NX.

Objective
Participants will receive tips, hints and background information from experienced tutors applicable to current projects.

Content
CAD with Siemens NX
- 2 day of intensive training (2x4h, 1x8L)
CAE mit Siemens NX
- 2 separate days of intensive training (2x8L)

Lecture notes
Lecture notes and documentation will be electronically available.

Prerequisites / notice
- only for students participating in a Focus Project in the same semester
- use of Siemens NX CAD/CAE in the corresponding Focus Project required

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Focus Specialization

Energy, Flows and Processes

Focus Coordinator: Prof. Christoph Müller

In order to achieve the required 20 credit points for the Focus Specialization Energy, Flows and Processes you need to choose at least 2 core courses (W+) (HS/FS) and at least 2 of the elective courses (HS/FS), according to the presentation of the Focus Specialisation (see https://ethz.ch/content/dam/ethz/special-interest/mavt/department-dam/studium/bachelor/documents/EFP_Focus.pdf). One course can be selected among all the courses offered by D-MAVT (Bachelors and Masters).

Number Title Type ECTS Hours Lecturers

Abstract
The course presents an overview of measurement tasks in engineering environments. Different concepts for the acquisition and processing of typical measurement quantities are introduced. Following an initial in-class introduction, laboratory exercises from different application areas (especially in thermofluidics, energy, and process engineering) are attended by students in small groups.

Objective
Introduction to various aspects of measurement techniques, with particular emphasis on thermo-fluidic, energy, and process-engineering applications.
Understanding various sensing technologies and analysis procedures.
Exposure to typical experiments, diagnostics hardware, data acquisition, and processing.
Study of applications in the laboratory.
Fundamentals of scientific documentation and reporting.

Content
In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy technology, process engineering)
Student participation in 8-10 laboratory experiments (study groups of 3-5 students, dependent on the number of course participants and available experiments)
Lab reports for all attended experiments have to be submitted by the study groups. A final exam evaluates the acquired knowledge individually.

Lecture notes
Presentations, handouts, and instructions are provided for each experiment.

Literature

Prerequisites / notice
Basic understanding in the following areas:
- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

151-0293-00L
Combustion and Reactive Processes in Energy and Materials Technology

Abstract
The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials.
The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials. The lecture is part of the focus "Energy, Flows & Processes" on the Bachelor level and is recommended as a basis for a future Master in the area of energy. It is also a facultative lecture on Master level in Energy Science and Technology and Process Engineering.


No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English


This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course "Introduction to Modeling and Optimization of Sustainable Energy Systems", the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

The global energy transition; Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

- Wall-bounded turbulent flows.
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.
- Origin and control of turbulence. Instability and transition.

In the course "Introduction to Photonics", theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.

Lecture notes


Lecture slides and supplementary documentation are available.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics I, Physics II

151-0917-00L Mass Transfer W 4 credits 2V+2U S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature

Prerequisites / notice
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0973-00L Introduction to Process Engineering W 4 credits 2V+2U F. Donat, C. Müller

Abstract
Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

Objective
We teach the fundamentals of process engineering using practical examples as well as concrete process engineering problems in the areas of process control and balancing, thermal separation processes, mechanical separation processes and reaction engineering.
Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

In addition to teaching basic theoretical knowledge, the focus is on solving typical problems in various subdisciplines of process engineering.

A script is provided (German language).

Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the lecture and the exercise materials are sufficient.

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### Mechatronics and Robotics

**Focus Coordinator: Prof. Marco Hutter**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Ahmed</td>
</tr>
</tbody>
</table>

**Abstract**
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

**Objective**
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

**Content**
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices.

**Lecture notes**

**Literature**

**Prerequisites / notice**
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and homework.

**Taught competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- **Personal Competencies**
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-direction and Self-management: assessed

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</thead>
<tbody>
<tr>
<td>151-0575-01L</td>
<td>Signals and Systems</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>A. Carron</td>
</tr>
</tbody>
</table>

**Abstract**
Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

**Objective**
Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

**Content**

**Lecture notes**
Lecture notes available on course website.

**Prerequisites / notice**
Control Systems I is helpful but not required.

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</thead>
<tbody>
<tr>
<td>151-0601-00L</td>
<td>Theory of Robotics and Mechatronics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>to be announced</td>
</tr>
</tbody>
</table>

**Abstract**
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robot systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**
available.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobots</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
</tbody>
</table>

**Abstract**
Microrobots is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamental aspects of the emerging field of microrobots. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobots. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1529 of 2345
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

The lecture will be taught in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0621-00L</td>
<td>Microsystems I: Process Technology and Integration</td>
<td>6 credits</td>
<td>M. Haluska, C. Hierold</td>
</tr>
<tr>
<td>151-0640-00L</td>
<td>Studies on Mechatronics</td>
<td>5 credits</td>
<td>Supervisors</td>
</tr>
<tr>
<td>151-0913-00L</td>
<td>Introduction to Photonics</td>
<td>4 credits</td>
<td>R. Quidant, J. Ortega Arroyo</td>
</tr>
</tbody>
</table>

Prerequisites:
- For exceptions please contact the focus coordinator and info@mavt.ethz.ch.
- This course is not available to incoming exchange students.

Content:
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of Microsystems and -devices by a sequence of defined processing steps (process flow).

Objective:
The students are familiar with the challenges of the fascinating and interdisciplinary field of Mechatronics and Microsystems. They are introduced in the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Content:
- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Application of selected technologies will be demonstrated on case studies.

Literature:
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites:
- Physics I and II

Abstract:
Overview of Mechatronics topics and study subjects. Identification of minimum 10 pertinent refereed articles or works in the literature in consultation with supervisor or instructor. After 4 weeks, submission of a 2-page proposal outlining the value, state-of-the-art and study plan based on these articles. After feedback on the substance and technical writing by the instructor, project commences.

Objective:
The students work independently on a study of selected topics in the field of Mechatronics or Microsystems. They start with a selection of scientific papers to continue literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

Literature will be available.

Abstract:
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective:
Photons, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Abstract
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Content
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; isolated DCDC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Lecture notes
Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice
Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the presented theoretical concepts. Additionally, for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html.
Physical Human Robot Interaction (PHRI)  
ECTS  
Students are introduced to the fundamentals of human-robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

Objective  
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de-sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content  
This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interactions on, 6(2):256 - 268.

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, virtual environment and teleoperator systems, 2006 14th Symposium on, pages 19 - 25.

of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans as well as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes  
Will be distributed on Moodle before the lectures.

Literature  


Prerequisites / notice  
The registration is limited to 26 students. There are 4 credit points for this lecture. The lecture will be held in English. The students are expected to have basic control knowledge from previous classes. http://www.relab.ethz.ch/education/courses/phri.html

Microsystems and Nanoscale Engineering

Focus Coordinator: Prof. Christofer Hierold

Number  | Title  | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
151-0621-00L | Microsystems I: Process Technology and Integration | W+ | 6 credits | 3V+3U | M. Haluska, C. Hierold

Data: 18.08.2022 12:39  
Autumn Semester 2022  
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### Objective

Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).

### Content

- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Application of selected technologies will be demonstrated on case studies.

### Lecture notes

Handouts (available online)

### Literature

- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- W. Menz, J. Mohr, O. Paul: Microsystem Technology
- J. Menz, O. Paul: Introduction to Microsystem Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

### Prerequisites

Prerequisites: Physics I and II

<table>
<thead>
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<th>Course</th>
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<th>Semester</th>
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</thead>
<tbody>
<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>4</td>
<td>W</td>
</tr>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>4</td>
<td>3G</td>
</tr>
<tr>
<td>151-0609-00L</td>
<td>Studies on Micro and Nano Systems</td>
<td>5</td>
<td>11A</td>
</tr>
</tbody>
</table>

### Abstract

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

### Objective

The course is designed to equip students with the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

### Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices.

### Lecture notes


### Literature


### Prerequisites

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Assessed</th>
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<tr>
<td>Social Competencies</td>
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<tr>
<td>Method-specific Competencies</td>
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<tr>
<td>Subject-specific Competencies</td>
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</tbody>
</table>

### Taught Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

### Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### Personal Competencies

- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

### 151-0643-00L

**Studies on Micro and Nano Systems**

This course is not available to incoming exchange students.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Supervisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0643-00L</td>
<td>Studies on Micro and Nano Systems</td>
<td>5</td>
<td>11A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

### Abstract

The students get familiarized with the challenges of the fascinating and interdisciplinary field of Micro- and Nanosystems. They are introduced to the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

### Objective

The students get familiarized with the challenges of the fascinating and interdisciplinary field of Micro- and Nanosystems. They are introduced to the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

### Content

Students work independently on a study of selected topics in the field of Micro- and Nanosystems. They start with a selection of scientific papers, and continue with an independent literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.
### Micro- and Nanoparticle Technology

**Number of participants:** limited to 20. Additional ones could be enrolled by permission of the lecturer.

**Abstract**

Particles are everywhere and nano is the new scale in science & engineering as micro was ~200 years ago. For highly motivated students, this exceptionally demanding class gives a flavor of nanotechnology with hands-on student projects on gas-phase particle synthesis & applications capitalizing on particle dynamics (diffusion, coagulation etc.), shape, size distribution and characterization.

**Objective**

This course aims to familiarize motivated M/BSc students with some of the basic phenomena of particles at the nanoscale, thereby illustrating the links between physics, chemistry, materials science through hands-on experience. Furthermore it aims to give an overview of the field with motivating lectures from industry and academia, including the development of technologies and processes based on particle technology with introduction to design methods of mechanical processes, scale-up laws and optimal use of materials and energy. Most importantly, this course aims to develop the creativity and sharpen the communication skills of motivated students through their individual projects, a PERFECT preparation for the M/BSc thesis (e.g. efficient & critical literature search, effective oral/written project presentations), the future profession itself and even life, in general, are always there!

**Content**

The course objectives are best met primarily through the individual student projects which may involve experiments, simulations or critical literature. Projects are conducted individually under the close supervision of MSc, PhD or post-doctoral students. Therein, a 2-page proposal is submitted within the first two semester weeks addressing explicitly, at least, 10 well-selected research articles and thoughtful meetings with the project supervisor. The proposal address 3 basic questions: a) how important is the project; b) what has been done already in that field and c) what will be done by the student. Detailed feedback on each proposal is given by the supervisor, assistant and professor two weeks later. Towards the end of the semester, a 10-minute oral presentation is given by the student followed by 10 minutes Q&A. A 10-page final report is submitted by noon of the last day of the semester. The project supervisor will provide guidance throughout the course. Lectures include some of the following:

- **Overview & Project Presentation**
- **Particle Size Distribution**
- **Particle Diffusion**
- **Coagulation**
- **Agglomeration & Coalescence**
- **Particle Growth by Condensation**
- **Control of particle size & structure during gas-phase synthesis**
- **Multi-scale design of aerosol synthesis of particles**
- **Particle Characterization**
- **Aerosol manufacture of nanoparticles**
- **Forces acting on Single Particles in a Flow Field**
- **Fixed and Fluidized Beds**
- **Separations of Solid-Liquid & Solid-Gas systems**
- **Emulsions/droplet formation/microfluidics**
- **Gas Sensors**
- **Coaching for proposal & report writing as well as oral presentations**

**Literature**


**Prerequisites / notice**

FluidMechanik I, Thermodynamik I&II & “clean” 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As exceptional effort will be required! Having seen "Chasing Mavericks" (2012) by Apted & Henson, "Unbroken" (2014) by Angelina Jolie and, in particular, “The Salt of the Earth” (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).

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### Introduction to Photonics

**W 6 credits 2V+2U**

**R. Quidant, J. Ortega Arroyo**

**Abstract**

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
Content

I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics I, Physics II

Additional Case for the Focus Specialization
Exclusive for D-MAVT Bachelor's students in Focus Specialization.
For enrollment, please contact the D-MAVT Student Administration.

Number Title Type ECTS Hours Lecturers
151-0135-00L Manufacturing I W+ 4 credits 2V+2U K. Wegener, M. Wiessner

Abstract
Deeper insight in manufacturing processes: drilling, milling, grinding, honing, lapping, electro erosion and electrochemical machining.

Objective
Stability of processes, process chains and process choice.

Content
Deeper discussion on the machining processes and their optimisation. Outlook on additional areas such as NC-Technique, dynamics of processes and machines, chatter as well as process monitoring.

Prerequisites / notice
Prerequisites: Recommendation: Lecture 151-0700-00L Manufacturing elective course in the 4th semester. Language: Help for English speaking students on request as well as english translations of the slides shown.
The lecture teaches on the basic knowledge of major processes in sheet metal, tube and bulk metal forming technologies. In particular it focuses on fundamental computation methods, which allow a fast assessment of process behaviour and a rough layout. Process-specific states of stress and deformation are analysed and process limits are identified.

**Objective**

Acquaintance with forming processes. Determination of forming processes. Interpretation of forming manufacturing

**Content**

The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, ro extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.

**Lecture notes**

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<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0703-00L</td>
<td>Operational Simulation of Production Lines</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>Yes (withMaster Students)</td>
</tr>
<tr>
<td></td>
<td>The students learn the application of the event-driven and computer-based simulation for layout and operational improvement of production facilities by means of practical examples. The simulation provides an essential basis for digital twins in Industry 4.0. Operating simulation in the productions, logistic and scheduling will be shown by means of practical examples. The students should make their first experiences in the use of computer-based simulation.</td>
<td>Conceptual</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example. A bibliography will be given during the lectures. Will be sent by email before the lecture (pdf).

**Prerequisites**

Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (NAVT, MTEC).

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Sensitivity to Diversity

**Social Competencies**

- Cooperation and Teamwork
- Customer Orientation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0717-00L</td>
<td>Mechanical Production: Assembly, Joining and Coating Technology</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>Yes (withMaster Students)</td>
</tr>
<tr>
<td></td>
<td>Understanding of the complexity of the assembly process as well as its meaning as success and cost factor. The assembly with the different aspects of adding, moving, adjusting, controlling parts etc., Adding techniques; solvable and unsolvable connections. Assembly plants. Coating techniques and their tasks, in particular corrosion protection.</td>
<td>Conceptual</td>
<td></td>
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</table>

To understand assembly in its full complexity and its paramount importance regarding cost and financial success. An introduction into a choice of selected joining and coating techniques. Assembly processes and their specific applications, with particular emphasis on corrosion protection.

**Lecture notes**

Yes (withMaster Students)

**Prerequisites / notice**

Recommended to the focus production engineering. Majority of lecturers from the industry.

**Subject-specific Competencies**

- Knowledge of process}
- principal design of machine tools
- errors of linear and rotational axes and of machine tools,
- influence of errors on the workpiece (error budgeting), with testing of drives and numerical control, as well as with checking the machine tool capability.

**Technique Specific Competencies**

- Geometric and kinematics of the machine tools
- Geometric and kinematics of the workpiece
- Geometric and kinematics of the tool
- Measurement data acquisition / digital signal analysis
- Experimental modal analysis
- Geometric, kinematic, thermal, dynamic testing of machine tools
- Test uncertainty
- Machine tool capability

**Technological Competencies**

- Machine tool and part design
- Machine tool and part manufacturing
- Machine tool and part assembly
- Machine tool and part testing

**Organizational Competencies**

- Organization and management of production systems
- Organization and management of production processes
- Organization and management of production facilities

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<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>151-0719-00L</td>
<td>Quality of Machine Tools - Dynamics and Metrology at Micro and Submicro Level</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
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<tr>
<td></td>
<td>The course “Machine tool metrology” deals with the principal design of machine tools, their spindles and linear axes, with possible geometric, kinematic, thermal and dynamic errors of machine tools and testing these errors, with the influence of errors on the workpiece (error budgeting), with testing of drives and numerical control, as well as with checking the machine tool capability.</td>
<td>Conceptual</td>
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</table>

Knowledge of process
Nothing works without electronics! Typical products in mechanical engineering such as machine tools, as well as any kind of vehicle contain a significant amount of electric or electronic components of more than 60%. Thus, it is important to master the value added process sequence for electric and electronic components.

The lecture starts with a brief introduction of electronic components and the planning of integrated circuits. Next, an overview will be provided about electronic functional units assembled from these electronic components, on printed circuit boards as well as in hybrid technology. Value added process steps are shown as well as their quality check and their combination for planning a complete manufacturing line. The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics will described too.

The lecture concludes with an excursion to a large manufacturing company. Here, students can see the application and realization of the manufacturing of electric and electronic devices.

The lecture is partly given by experts from industry. It is supplemented by an excursion to one of the industry partners.

Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

1. Introduction into FEM
2. Fundamentals of continuum mechanics to characterize large plastic deformations
3. Elasto-plastic material models
4. Lagrange and Euler approaches
5. FEM implementation of constitutive equations
6. Element formulations
7. Implicit and explicit FEM methods
8. FEM formulations of coupled thermo-mechanical problems
9. Modeling of tool contact and the influence of friction
10. Solvers and convergence
11. Instability problems

Lecture slides

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Ahmed</td>
</tr>
</tbody>
</table>

**Abstract**

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

**Objective**

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

**Content**

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

**Lecture notes**


**Literature**


**Prerequisites / notice**

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

**Taught competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
- **Social Competencies**
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- **Personal Competencies**
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-direction and Self-management

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<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>151-0524-00L</td>
<td>Continuum Mechanics I</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>A. E. Ehret</td>
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</table>

**Abstract**

The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

**Objective**

Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.

**Content**

Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments

**Lecture notes**

Yes

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-0604-00L</td>
<td>Microrobots</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
</tbody>
</table>

**Abstract**

Microrobots is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

**Content**

Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

**Lecture notes**

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

**Prerequisites / notice**

The lecture will be taught in English.

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>151-0621-00L</td>
<td>Microsystems I: Process Technology and Integration</td>
<td>W</td>
<td>6 credits</td>
<td>3V+3U</td>
<td>M. Haluska, C. Hierold</td>
</tr>
</tbody>
</table>

**Abstract**

Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).

**Objective**

Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).

**Content**

- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

**Application of selected technologies will be demonstrated on case studies.**

**Lecture notes**

Handouts (available online)

**Literature**

- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

**Prerequisites / notice**

Prerequisites: Physics I and II
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques.

Objective

The students are familiar with the challenges of the fascinating and interdisciplinary field of Engineering for Health. They are introduced in the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Content

The students work independently on a study of selected topics in the field of Studies on Engineering for Health. They start with a selection of scientific papers to continue literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

Literature
Will be available.

Biomedical Imaging

Abstract
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

Objective
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

Content

- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Prerequisites / notice
Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

Bioelectronics and Biosensors

Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field

Lecture notes
Lecture notes and handouts

Literature
Content

L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomeasurement techniques with photons

L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes

L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a Faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation

L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
The objective of this course is to give an introduction to the fundamentals of physical human-robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1. identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2. compare and select mechatronic components that optimally fulfill the defined design requirements;
3. derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4. design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5. characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6. investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes
Will be distributed on Moodle before the lectures.

Literature

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Prerequisites / notice
Notice:
The registration is limited to 26 students.
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.
http://www.relab.ethz.ch/education/courses/phri.html

376-1714-00L Biocompatible Materials W 4 credits 3V K. Maniura, M. Rottmar, M. Zenobi-Wong

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Handouts are deposited online (moodle).

Literature:

(available online via ETH library)

Handouts and references therein.

Management, Technology, and Economics
Focus Coordinators: Prof. Stefano Brusoni D-MTEC and Swantje Pless D-MTEC

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0733-00L</td>
<td>Basics and Processes of Metal Forming</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Bambach</td>
</tr>
</tbody>
</table>

Note: The previous course title until HS21 "Forming Technology III - Forming Processes".

Abstract
The lecture teaches on the basic knowledge of major processes in sheet metal, tube and bulk metal forming technologies. In particular it focuses on fundamental computation methods, which allow a fast assessment of process behaviour and a rough layout. Process-specific states of stress and deformation are analysed and process limits are identified.

Objective
Acquaintance with forming processes. Determination of forming processes. Interpretation of forming manufacturing

Content
The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, ro extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.

Lecture notes
Handouts and references therin.

Literature

363-0445-00L Production and Operations Management  W+  3 credits  2G  T. Netland, H. Franke

Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:
1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Content
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

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### Taught competencies

<table>
<thead>
<tr>
<th>Competency Area</th>
<th>Competency</th>
<th>Taught by</th>
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<tbody>
<tr>
<td><strong>Subject-specific Competencies</strong></td>
<td>Concepts and Theories</td>
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<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td><strong>Method-specific Competencies</strong></td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<td>Project Management</td>
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<td><strong>Social Competencies</strong></td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Negotiation</td>
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<td><strong>Social Competencies</strong></td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
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<td><strong>Personal Competencies</strong></td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Self-direction and Self-management</td>
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</table>

### Systems Dynamics and Complexity

**Abstract**

Finding solutions: what is complexity, problem solving cycle.

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption.

**Objective**

A successful participant of the course is able to:

- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

**Content**

Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.

The course is structured along three main tasks:

1. **Finding solutions**
2. **Implementing solutions**
3. **Controlling solutions**

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see "Prerequisites").

**Lecture notes**

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

### Systems Dynamics and Complexity (Additional Cases)

**Abstract**

This module is an addition to the course Systems Dynamics and Complexity. It offers additional study cases to MAVT Bachelor students who enroll in the main course.

**Objective**

MAVT Bachelor students learn how to develop and analyze more sophisticated systems dynamics models from different areas, e.g. from biology (population dynamics, cooperation), management (inventory modeling, technology adoption and economics (supply and demand, investment and consumption), to name but a few. The goal is to apply analytical and numeric techniques to gain a deeper understanding of the dynamics of complex systems.
1. Modelling path dependence and formation of standards
   - Why do clocks go clockwise? Why do people in most nations drive on the right? Why do nearly all computer keyboards have the QWERTY layout, even though it is more inefficient compared to DVORAK? It turns out that many real-world processes are path dependent, i.e., small random events early in their history determine the ultimate end state, even when all end states are equally likely at the beginning. Students will learn how to model such processes, to understand the feedback mechanisms that lead to path dependence. As a case in point, we will study the ‘war’ between the Betamax and the VHS standards.

2. Optimal migration as promoter of cooperation
   - Mechanisms to promote cooperative behaviour is a vibrant research topic in various fields - economics, evolutionary biology and management science to name but a few. Students will be introduced to one such mechanism - migration. They will develop and analyse a macroscopic model to study how the rate of migration affects the long-term cooperation rate in a population.

3. Information transfer
   - Information flow in a social system (e.g. about the location of resources or appearance of a competitor) is an important component of group living. For example, it is well known that ants can achieve remarkable feats in finding an optimal route to a food patch through pheromone trails. The goal of this study case is to model information transfer in such systems by investigating the dynamics of trail formation in ants. The students will learn that the complexity in navigating to a food source may nevertheless be explained as a simple dynamical system with one control parameter only.

4. Decisions in social societies
   - In many situations individuals have to decide between two or more options. Such decisions often have a profound impact on the system as a whole, especially regarding group cohesion. Group cohesion is preferred, as individuals can benefit from living in groups, yet it may not be the underlying reason behind individual choices. In this case, students will develop and extend a macroscopic model of an animal social system faced with a decision to choose a new home, and identify the conditions which promote group cohesion versus group splitting.

5. Antigenic variation of HIV
   - One of the characteristic traits of HIV is that a host can be a carrier and a transmitter of the virus without experiencing symptoms for up to 10 years. This case is concerned with finding the mechanism of HIV disease progression. The students will develop a general population-based model for the interaction of an infectious agent with the host immune system. The model is applicable to a variety of infectious agents, ranging from acute lethal infections to chronic illness. Through analysing and simulating the model, the students will understand how the HIV virus interacts with the host and how the mutation rate of the virus is ultimately responsible for this long asymptomatic period.

6. Compartmental models in epidemiology
   - Many diffusive processes in social systems, such as epidemics, can be understood as a result of the interaction between a few groups (compartments) of individuals. The most common example is to divide a population into those who are susceptible (S) to a disease, those who are infected (I), and those who have recovered (R) and are immune, and to model their interactions. These so called SIR models find wide application in studying non-biological diffusive processes, e.g. spread of technological innovations, fads, internet memes etc. In this study case, students will become familiar with the basic components of an SIR model and the conditions under which a disease can cause the outbreak of an epidemic. Students will extend the basic model to investigate more realistic scenarios relevant to e.g. different vaccination strategies.

Lecture notes: Will be provided

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Group</th>
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</thead>
<tbody>
<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Exercises) 351-0778-01.</td>
<td>W 3 credits 3G</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
</tr>
</tbody>
</table>

Abstract

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
(1) broaden understanding of management principles and frameworks
(2) advance insights into the sources of corporate and entrepreneurial success
(3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

Content

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Lecture notes

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<th>Personal Competencies</th>
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<tbody>
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<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<tr>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Assessed</td>
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Data: 18.08.2022 12:39
Autumn Semester 2022
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In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share their insights on corporate sustainability with you. Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

Students have the option to either write this alone or in a group of two students.

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

This lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share their insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

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This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems. This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

The set-up of the course will closely follow the book of N. Gregory Mankiw and Mark P. Taylor (2020), Economics, Cengage Learning, Fifth Edition. This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

### Taught competencies

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<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
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<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
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### Literature

The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

**Objective**

- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

**Content**

The first part of the course is devoted to financial accounting. It teaches the principles of double-entre accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

**Prerequisites / notice**

This course is a prerequisite for the course Financial Management.

### Technology Entrepreneurship

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

**Objective**

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real-life examples and cases.
Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating

The students would cover the following topics, as the build their idea into a business case:

- **Enabling Entrepreneurship: From Science to Startup**
- **Lecture slides and case material**

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

This course is relevant for those students who aspire to become entrepreneurs.

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialize through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch.

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.
Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
1) the economics of insurance
2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
6) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume 1;

Further readings:

References will be given on a topic-by-topic basis during the course.

Taught competencies
Method-specific Competencies
Media and Digital Technologies
Project Management

Social Competencies
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility

Personal Competencies
Creative Thinking
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies
Problem-solving

Personal Competencies
Critical Thinking

Introduction to Microeconomics
GESS (Science in Perspective):
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.
Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Subject: Design, Mechanics and Materials

Focus Coordinator: Prof. Kristina Shea

In order to achieve the required 20 credit points for the Focus Specialization Design, Mechanics and Material you are free to choose any of the courses offered within the focus and are encouraged to select among those recommended. If you wish to take one of the Master level courses, you must get approval from the lecturer.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0364-00L</td>
<td>Lightweight Structures Laboratory</td>
<td>W+</td>
<td>4</td>
<td>5A</td>
<td>M. Zogg, P. Ermanni</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>Teams of 2 to 3 students have to design, size, and manufacture a lightweight structure complying with given specifications. An aircraft wing spar prototype as well as later a second improved spar will be tested and assessed regarding to design and to structural mechanical criteria.</td>
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<td>To develop the skills to identify and solve typical problems of the structure mechanics on a real application. Other important aspects are to foster team work and team spirit, to link theoretical knowledge and practice, to gather practical experiences in various fields related to lightweight structures such as design, different CAE-methods and structural testing.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>The task of each team (typically 2-2 students) is the realization of a reduced-scale aircraft wing spar, a typical load-carrying structure, with selected materials. The teams are free to develop and implement their own ideas. In this context, specified requirements include information about loads, interface to the surrounding structures.</td>
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<td>The project is structured as described below:</td>
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<td>- Concept development</td>
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<td>- design of the component including FEM simulation and stability checks</td>
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<td>- manufacturing and structural testing of a prototype</td>
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<td>- manufacturing and structural testing of an improved component</td>
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<td>- cost assessment</td>
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<td>- Report</td>
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<td>The project work is supported by selected teaching units.</td>
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<tbody>
<tr>
<td>151-3207-00L</td>
<td>Lightweight</td>
<td>W+</td>
<td>4</td>
<td>2V+2U</td>
<td>P. Ermanni</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The elective course Lightweight includes numerical methods for the analysis of the load carrying and failure behavior of lightweight structures, as well as construction methods and design principles for lightweight design.</td>
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<td><strong>Objective</strong></td>
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<td>The goal of this course is to convey substantiated background for the understanding and the design and sizing of modern lightweight structures in mechanical engineering, vehicle and airplane design.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>Lightweight design</td>
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<td>Thin-walled beams and structures</td>
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<td>Instability behavior of thin walled structures</td>
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<td>Reinforced shell structures</td>
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<td>Load introduction in lightweight structures</td>
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<td>Joining technology</td>
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<td>Sandwich design</td>
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<tr>
<td>151-3213-00L</td>
<td>Integrative Ski Building Workshop</td>
<td>W+</td>
<td>4</td>
<td>9P</td>
<td>K. Shea</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>To apply, please send the following information to <a href="mailto:jchapuis@ethz.ch">jchapuis@ethz.ch</a> by 31.08.2022: Letter of Motivation (one page) , CV, Transcript of Records.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>This course introduces students to engineering design and fabrication by building their own skis or snowboard. Theoretical and applied engineering design skills like CAD, analysis and engineering of mechanical properties, 3D printing, laser cutting and practical handcrafting skills are acquired in the course.</td>
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</tbody>
</table>

Autumn Semester 2022

Data: 18.08.2022 12:39
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing. Students will learn how ultrasound can be used in additive manufacturing for tissue constructs and robotics. Furthermore, the course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases.

### Literature


### Prerequisites / notice

- Willingness to engage in the practical building of your ski/board also beyond the course hours in the evening.

### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

### Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### Personal Competencies

- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

### Content

- Introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.
- The main objectives of this lecture are:
  - Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
  - Understanding the importance of material science and metallurgical considerations in MAM,
  - Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
  - Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.

### Prerequisites / notice

- No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

### Prerequisites / notice

- A basic knowledge of mechanical analysis, metallurgy; thermodynamics is recommended.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
</table>

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Creative Thinking
- Critical Thinking

### 151-3209-00L Engineering Design Optimization

| W | 4 credits | 4G | K. Shea, T. Stankovic |

**Abstract**
The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them.

**Objective**
The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.

**Content**
1. Optimization modeling and theory
2. Unconstrained optimization methods
3. Constrained optimization methods - linear and non-linear
4. Direct search methods
5. Stochastic and evolutionary search methods
6. Multi-objective optimization

**Lecture notes**
available on Moodle

### 327-1204-00L Materials at Work I

| W | 4 credits | 4S | R. Spolenak, E. Dufresne, R. Koopmans |

**Abstract**
This course attempts to prepare the student for a job as a materials engineer in industry. The gap between fundamental materials science and the materials engineering of products should be bridged. The focus lies on the practical application of fundamental knowledge allowing the students to experience application related materials concepts with a strong emphasis on case-study mediated learning.

**Objective**
Teaching goals:
- to learn how materials are selected for a specific application
- to understand how materials around us are produced and manufactured
- to understand the value chain from raw material to application
- to be exposed to state of the art technologies for processing, joining and shaping
- to be exposed to industry related materials issues and the corresponding language (terminology) and skills
- to create an impression of how a job in industry "works", to improve the perception of the demands of a job in industry

**Content**
This course is designed as a two semester class and the topics reflect the contents covered in both semesters.

- Lectures and case studies encompass the following topics:
  - Strategic Materials (where do raw materials come from, who owns them, who owns the IP and can they be substituted)
  - Materials Selection (what is the optimal material (class) for a specific application)
  - Materials systems (subdivisions include all classical materials classes)
    - Processing
    - Joining (assembly)
    - Shaping
  - Materials and process scaling (from nm to m and vice versa, from mg to tons)
  - Sustainable materials manufacturing (cradle to cradle)
  - Recycling (Energy recovery)

- After a general part of materials selection, critical materials and materials and design four parts consisting of polymers, metals, ceramics and coatings will be addressed.

- In the fall semester the focus is on the general part, polymers and alloy case studies in metals. The course is accompanied by hands-on analysis projects on everyday materials.

**Literature**
Manufacturing, Engineering & Technology
Serope Kalpakjian, Steven Schmid
ISBN: 978-0131489653

**Prerequisites / notice**
Profound knowledge in Physical Metallurgy and Polymer Basics and Bachelor Level by the following lectures: Metalle 1, 2; Polymere 1,2

### 5. Semester: Engineering Tools

The Engineering Tools courses are for MAVT Bachelor's degree students only.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0015-10L</td>
<td>Engineering Tool: Experimental Modal Analysis</td>
<td>W</td>
<td>0.4 credits</td>
<td>1K</td>
<td>D. Spescha</td>
</tr>
</tbody>
</table>

All Engineering Tools courses are for MAVT Bachelor's degree students only.

**Abstract**
Measuring and analysis methods for the determination of transfer functions of mechanical structures. Evaluation and preparation of the measured data for visualisation and interpretation of the dynamic behaviour.

**Objective**
Handling of accelerometers and force transducers, measurement of transfer functions of mechanical structures, determination and visualisation of vibration modes using practical examples, introduction to vibration theory and its fundamental terms.

**Lecture notes**
German documents are provided during the course.

**Prerequisites / notice**
In the practical part of the course, the participants will carry out measurements on structures themselves and then analyse them with respect to natural frequencies and vibration modes.

| 151-0025-10L | Engineering Tool: Introduction to CAM and Motion Simulation | W | 0.4 credits | 1K | M. Schmid |

All Engineering Tools courses are for MAVT Bachelor's
Introduction of integrated CAD applications CAM (Computer Aided Manufacturing), Motion Simulation (Kinematics)  

**Objective**  
The participants learn the possibilities of integrated CAD applications. The goal is to understand the procedures and the most important functions of these applications.

**Content**  
- CAM (Computer Aided Manufacturing):  
  - Introduction to CAM  
  - Practical examples for 3-axle milling machine and Feature Based Machining  
- Motion Simulation (Kinematics/Dynamics):  
  - Introduction and practical examples

**Prerequisites / notice**  
- CAD-Grundkenntnisse in Siemens NX (CAD 1. Semester)  
- Verwenden Sie zur Durchführung der Übungen wenn möglich Ihr eigenes Laptop. Siemens NX kann im ETH IT-Shop kostenlos bestellt werden. Es stehen einige Rechner zur Verfügung.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semesters</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0027-10L</td>
<td>Engineering Tool: Programming with LabView</td>
<td>0.4</td>
<td>W</td>
<td>L. Prochazka</td>
</tr>
<tr>
<td>151-0030-10L</td>
<td>Engineering Tool: Modelling and Servo Axis Control of Machine Tool Manipulators</td>
<td>0.4</td>
<td>W</td>
<td>O. Zirn</td>
</tr>
<tr>
<td>151-0032-10L</td>
<td>Engineering Tool: Introduction to the Methods of Six Sigma Quality Control and Lean Production</td>
<td>0.4</td>
<td>W</td>
<td>B. G. Rüttimann</td>
</tr>
</tbody>
</table>

An introduction is given to the LabView programming environment. The basic concepts of "virtual instruments" and data flow programming are presented. Computer-based exercises are solved during class. A simple electronic data acquisition module is used to demonstrate basic concepts of interface management and data acquisition.

**Objective**  
Introduction to the LabView programming environment. Understanding of fundamental concepts: virtual instruments, data flow programming, control structures, data types etc. Development of basic programming skills using in-class exercises on computers.

This course covers model building and the applied stimulation of (power-assisted axles on production machinery using MATLAB/Simulink and provides a practical example of how drive parameters may be set up, how through simulation an optimal axis design can be developed and which characteristics of a production machine can be reliably estimated in advance.

**Objective**  
The students are able to model servo axes considering all relevant components and process influences to simulate the achievable productivity.

1. Introduction, complexity levels in model building for production machines.  
2. Servo axis feedback control, cascade controller  
3. Numerical control systems, setpoint generation  
4. Simulation examples in MATLAB/Simulink  
5. Outlook longitudinal model for battery electric vehicles

Wird abgegeben

**Prerequisites / notice**  
Prerequisites: Matlab skills; your laptop with Matlab/Simulink may be useful.

The course introduces to Six Sigma quality management and quality improvement, which aims to reduce process variation and to sustain process capability. It introduces also to the Lean production principles, aiming to reduce waste within the processes as well as aiming to a customer taked JIT pull-production.

**Objective**  
The participant gets an overview to the Operational Excellence philosophy and the working methods of these two approches. He learns the most important tools and the interaction of these two approaches. Introduction to the theory-specific aspects of Lean.
1. Understanding the changing environment
   - Globalization, customer requirements, production systems
   - Six Sigma quality philosophy
   - Lean Manufacturing and TPS (Toyota Production System)

2. Quality management with Six Sigma
   - What is Six Sigma
   - DMAIC problem solving approach
   - Use of different control charts
   - Evaluate process capability, DPMO, Cp, Cpk, Taguchi
   - Cause-effect diagram
   - Control plan and sustainability, PDCA

3. Introduction to the Lean approach
   - TPS model, Lean goals and principles
   - A3 project management
   - The 9 types of waste
   - Value add and non value add activities
   - The 8 Lean-Tools, whereof 4
   - 5S workplace organization
   - Value stream mapping (excercise), Little's law, process metrics
   - Continuous flow vs batch
   - Pull Principles, Kanban, DBR
   - Cell design
   - Linear Programming

4. Lean and Six Sigma in practice
   - How fits Lean and Six Sigma together
   - Continuous Improvement/Kaizen organization
   - Change-Management, risks
   - Inspire OPEX deployment approach

Lecture notes
Notes will be distributet.

Literature
empfohlen:

- Ohno, Toyota Production System - Beyond Large Scale Production, Productivity Press, New York, 1988
- Töpfer, Six Sigma - Konzeption und Erfolgsbeispiele für praktizierte Null-Fehler Qualität, Springer, 2007

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
<th>Techniques and Technologies</th>
<th>assessed</th>
</tr>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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</tbody>
</table>

151-0047-00L  Engineering Tool: Agile Product Development  
W  0.4 credits  1K  M. Meboldt

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Abstract
Agile product development is gaining high interest in many industries. Still, only few hardware developing firms have adopted Agile approaches into their daily development work due to inadequate trainings. Within this course, students will be introduced to the culture and mindset behind Agile by solving a practical development task in a team of 4 students.

Objective
Students shall experience and internalize the key principles and practices of Agile product development.

Content
Introduction to Agile (principles & methods), team-based development task.

Lecture notes
A digital script will be distributed.

151-0057-10L  Engineering Tool: Systems Engineering for Project Work  
W  0.4 credits  1K  R. Züst

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Abstract
The course is about a methodical basis of systematic project work, with a focus on demanding interdisciplinary problems. The participants will be shown how to use it appropriately and correctly in their projects. This short course is based on the "Systems Engineering" (SE) method, which was developed at the ETH.

Objective
The goals of this compact course are:
- Goal-oriented identification and perception of relevant problem areas and project goal setting.
- Deduction and development of procedures for a promising project, including systematic planning of the project content.
- Development of work packages including efficient methodology
- Simple embedding of the projects in the organization, including relationships with buyers, users and securing project participation.
1. Nachmittag: CAD refresher and top down modelling

The participants will deepen their existing CAD knowledge and learn new PDM knowledge, so that these may be directly applied and used in their work.

Engineering Tool: Scientific Writing with LaTeX and other software tools for managing documentation.


151-0059-10L Engineering Tool: CAD-Methodology and PDM-Technology in the Focus Project

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 25.

Content

Objectives

The participants will deepen their existing CAD knowledge and learn new PDM knowledge, so that these may be directly applied and used in the focus project.

- CAD refresh (Modelling, Assembling, Drafting, etc.) and CAD mythology for construction (Top-Down modelling)
- Introduction to the Team Center (Siemens PDM System)
- TeamCenter data flow, in particular the process of creating and managing new Items and Parts, the approval procedure and creating different versions of Parts
- The participants will learn and experiment with procedures by working on concrete examples so that they will subsequently be able to begin with independent product construction.
- The following topics will be dealt with in depth in the lectures supporting the focus project (Praxiskurs): CAD-Methodology, FE calculations, motion simulation and construction methodology.

Abstract

The participants learn about the procedures and tools that are necessary to develop technical products. The focus is on computer-based design and development in an integrated software environment.

Number of participants limited to 25.

Prerequisites / notice

- at least two students of a Focus-Team should sign in for this course, if the use of Siemens TeamCenter PLM is given for the Team.
- only for students participating in a Focus Project in the same semester
- not more than 25 students

151-0061-10L Engineering Tool: Scientific Writing with LaTeX and Vector Graphics

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 80.

Content

Abstract

This course provides insights into the structure and compilation of scientific papers and publications using LaTeX as well as open source software for image editing and the creation of vector graphics. LaTeX is a typesetting tool that separates text format and layout. It is widely used for reports and publications in the scientific domain.

Objective

By looking at specific examples during class you will obtain an overview on composing scientific papers (e.g. bachelor theses, seminar theses, master theses) using LaTeX and acquire the most important commands to typeset complex formulas, tables and graphics.

Number of participants limited to 80.

Content

- writing with LaTeX (structure, formatting, formulas, tables, graphics, references, table of contents, hyperlinks, packages) based on a template for bachelor/semester/master theses.
- graphic design and illustration using open source software and Matlab
- including PDF files in the report (project description, data sheets)
- managing bibliography databases
Students develop a basic understanding of the advantages and pitfalls of concurrency, and gain an overview of the field and its concepts.

Engineering Tool: Sketching and Visualization of Technical Concepts

- Participants acquire scientific writing basics as a core competency to communicate with different audiences. They apply important methods and tools to refine a scientific question, research and evaluate the necessary information, quote and paraphrase, and to plan the structure of their own text.

- Students are able to derive and structure ideas for a text starting from a scientific question using simple techniques
- Students are able to find literature sources, check their relevance and completeness, organize them with a suitable tool and cite correctly
- Students are able to apply a reading technique for summarizing a text
- Students are able to distinguish plagiarism, quotation and paraphrase in texts using the presented criteria and correctly cite or paraphrase external content
- Students are able to plan and structure specialized texts that refer to different target groups

KURSPROGRAMM

- LEHRFORMEN
  - Inputs: Kurzvorträge und Selbstleersequenzen
  - Übungen: Hausaufgaben und während des Nachmittags selbständig in Moodle anhand von Fallstudien
  - Feedback und Diskussion: Lösungen der Studierenden werden gemeinsam mit den Dozierenden besprochen und diskutiert

Prerequisites / notice

- Zu allen Inhaltsteilen gibt es Übungsteile in Moodle, für die ein Laptop mit funktionierendem Internetanschluss benötigt wird.

- Computer for exercises during the afternoon

151-0062-10L Engineering Tool: Computer-Aided Design Methods

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 25.

Abstract

Participants will learn about the Computer-Aided Design fundamentals and methods that are necessary to model complex technical products. The focus will be placed on feature-based and parametric modeling that is common to all modern CAD tools used in mechanical design.

Objective

CAD knowledge and skills will be further developed to enable students to recognize both the advantages and the limitations of current Computer-Aided Design tools. Examples of how to build feature-based and parametric models including design automation will be given along with common pitfalls. After taking the course students should be able to independently create effective feature-based and parametric models of mechanical parts.

Content

1. CAD Methods and Feature-Based Design (2 afternoons):
   - CAD in the context of the design process
   - Feature types and their relation to mechanical design
   - Strategies for building feature-based assemblies
   - Integration of digital part libraries
   - Common issues and difficulties with feature interaction

2. CAD and Parametric Modeling (1 afternoon):
   - Designing and building parametric models
   - Design automation to create design variants
   - Common issues and difficulties with parametric modeling

Lecture notes

available on Moodle

151-0067-10L Engineering Tool: Sketching and Visualization of Technical Concepts

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 20.

Abstract

This course is offered by the Design and Technology Lab Zurich. Effective visualizations of ideas are essential to communicate technical concepts. This course focusses on the basics of a coherent draft design through forms of sketches using various simple techniques.

Objective

Mastering various simple techniques for the visualization of technical ideas.

Content

Basics in: Perspective, line drawing, proportions, implementation of the plan views of perspective will be distributed

Lecture notes

It requires no further books

Literature

Material: Paper and pens

Prerequisites / notice

Max 20 participants

151-0091-10L Engineering Tool: Scientific Writing

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Abstract

Participants acquire scientific writing basics as a core competency to communicate with different audiences. They apply important methods and tools to refine a scientific question, research and evaluate the necessary information, quote and paraphrase, and to plan the structure of their own text.

Objective

Students are able to:
- derive and structure ideas for a text starting from a scientific question using simple techniques
- find literature sources, check their relevance and completeness, organize them with a suitable tool and cite correctly
- apply a reading technique for summarizing a text
- distinguish plagiarism, quotation and paraphrase in texts using the presented criteria and correctly cite or paraphrase external content
- use and cite information from the Internet correctly
- plan and structure specialized texts that refer to different target groups

KURSPROGRAMM

LEHRFORMEN

- Inputs: Kurzvorträge und Selbstleersequenzen
- Übungen: Hausaufgaben und während des Nachmittags selbständig in Moodle anhand von Fallstudien
- Feedback und Diskussion: Lösungen der Studierenden werden gemeinsam mit den Dozierenden besprochen und diskutiert

Prerequisites / notice

Computer for exercises during the afternoon

252-0864-00L Engineering Tool: Parallel and Concurrent Programming in C++

All Engineering Tool courses are for MAVT-Bachelor students only.

Abstract

This course provides an introduction to parallel and concurrent programming, using C++. Basic challenges and concepts will be introduced and illustrated, and applied by students in small projects.

Objective

Students develop a basic understanding of the advantages and pitfalls of concurrency, and gain an overview of the field and its concepts. They learn how to solve small problems using concurrent programs.

Prerequisites / notice

The course can only be passed if the projects are successfully implemented and submitted. If no or insufficient solutions are submitted, the course is considered failed.

Workshop Training
### Laboratory Practice

Students attend at least 10 Laboratory Practices during the 4th and 5th semester. 4 of them must be Physics laboratories. All laboratory works are graded "pass" or "fail". After completion of 10 laboratory training units, 2 credit points will be issued.

Please register online at www.mavt.ethz.ch/praktika

### Bachelor's Thesis

#### 151-0001-10L Bachelor's Thesis

Only for Mechanical Engineering BSc, Programme Regulations 2010.

**Supervisor for the Bachelor's Thesis:**
- All D-MAVT professors (https://www.mavt.ethz.ch/the-department/people/professors.html)

**Abstract**
The Bachelor's Thesis is the culmination of the program. The thesis corresponds to a work load of 420 hours and can be done in part- or full-time.

**Objective**
The students develop, enhance and demonstrate their methodological abilities to independently tackle and solve a given research problem.

**Content**
The topics for the bachelor's thesis are published by the professorship or they can be set in consultation between the professors and the students. Thesis projects in cooperation with the industry are also possible.

**Prerequisites / notice**
The Bachelor's Thesis can be only started when the First Year Examinations, the Additional First Year Courses, the Examination Block 1 and 2 are passed. It is strongly recommended for students to only begin the Bachelor's Thesis if 150 credit points have been achieved.

**Declaration of originality**
The declaration of originality is an integral part of the Bachelor's Thesis

#### 151-3630-00L Bachelor's Thesis (Focus Specialization Management, Technology and Economics)

Only for Mechanical Engineering BSc, Programme Regulations 2010.

**Supervisor for the Bachelor's Thesis:** All D-MTEC professors (https://www.mtec.ethz.ch/people/professors.html)

**Abstract**
The Bachelor's Thesis is the culmination of the program. The thesis corresponds to a work load of 420 hours and can be done in part- or full-time.

**Objective**
The students develop, enhance and demonstrate their methodological abilities to independently tackle and solve a given research problem.

**Content**
The topics for the bachelor's thesis are defined by the professorship or can be set in consultation between the professors and the students.

**Prerequisites / notice**
The Bachelor's Thesis can be only started when the First Year Examinations, the Additional First Year Courses, the Examination Block 1 and 2 are passed. Exclusively D-MAVT students who have enrolled for the Focus Specialization Management, Technology and Economy are eligible for this type of Bachelor's Thesis. It is strongly recommended for students to only begin the Bachelor's Thesis if 150 credit points have been achieved.

**Declaration of originality**
The declaration of originality is an integral part of the Bachelor's Thesis

### Science in Perspective

#### Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

**Recommended Science in Perspective (Type B) for D-MAVT**

### Language Courses

see Science in Perspective: Language Courses ETH/UZH
<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
High Performance Computing for Science and Engineering (HPCSE) I

Number: 151-0107-20L
Title: High Performance Computing for Science and Engineering (HPCSE) I
Type: W
ECTS: 4 credits
Hours: 4G
Lecturers: S. M. Martin, J. H. Walther

Abstract:
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

Objective:
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content:
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes:
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/
Class notes, handouts

Literature:
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0109-00L</td>
<td>Turbulent Flows</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U P. Jenny</td>
</tr>
<tr>
<td>Abstract</td>
<td>Contents - Laminar and turbulent flows, stability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scaings, homgeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows</td>
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<tr>
<td>Objective</td>
<td>Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling</td>
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<tr>
<td>Content</td>
<td>Properties of laminar, transitional and turbulent flows - Origin and control of turbulence, Instability and transition - Statistical description, averaging, equations for mean and fluctuating quantities, closeup problem - Scaings, homgeneous isotropic turbulence, energy spectrum - Turbulent free shear flows, Jet, wake, mixing layer - Wall-bound turbulent flows - Turbulent flow computation and modeling</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes are available</td>
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<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0125-00L</td>
<td>Hydrodynamics and Cavititation</td>
<td>W</td>
<td>4 credits</td>
<td>3G O. Supponen</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.</td>
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<tr>
<td>Objective</td>
<td>The main learning objectives of this course are: 1. Identify and describe dominant effects in liquid fluid flows through physical modelling. 2. Identify hydrodynamic instabilities and discuss the stability region 3. Describe fragmentation of liquids 4. Explain tension, nucleation and phase-change in liquids. 5. Describe hydrodynamic cavitatiion and its consequences in physical terms. 6. Recognise experimental techniques and industrial and medical applications for cavitiation.</td>
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<tr>
<td>Content</td>
<td>The course gives an overview on the following topics: hydrostatics, capillarity, hydrodynamic instabilities, fragmentation. Tension in liquids, phase change. Cavitiation: single bubbles (nucleation, dynamics, collapse), cavitating flows (attached, cloud, vortex cavitiation). Industrial applications and measurement techniques.</td>
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<tr>
<td>Lecture notes</td>
<td>Class notes and handouts</td>
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<tr>
<td>Literature</td>
<td>Literature will be provided in the course material.</td>
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<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>151-0163-00L</td>
<td>Nuclear Energy Conversion</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U A. Manera</td>
</tr>
<tr>
<td>Abstract</td>
<td>Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding</td>
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<tr>
<td>Objective</td>
<td>Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.</td>
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<tr>
<td>Content</td>
<td>Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the rector core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of rector technology.</td>
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<tr>
<td>Lecture notes</td>
<td>Hand-outs will be distributed. Additional literature and information on the website of the lab: <a href="https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00l-nuclear-energy-conversion.html">https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00l-nuclear-energy-conversion.html</a></td>
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R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

<table>
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<tr>
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<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4 credits</td>
<td>3G A. Steinfeld, E. I. M. Casati</td>
</tr>
<tr>
<td>Abstract</td>
<td>Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.</td>
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<tr>
<td>Objective</td>
<td>Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture Notes containing copies of the presented slides.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.</td>
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<tr>
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<th>Credits</th>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>151-0213-00L</td>
<td>Fluid Dynamics with the Lattice Boltzmann Method</td>
<td>W</td>
<td>4 credits</td>
<td>3G I. Karlin</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.</td>
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<tr>
<td>Objective</td>
<td>Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.</td>
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<tr>
<td>During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.</td>
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<tr>
<td>Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).</td>
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<td>The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.</td>
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<td>Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.</td>
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</table>
**Content**

The course builds upon three parts:

I. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.

II. Theoretical basis of statistical mechanics and kinetic equations.

III. Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. **Background: Elements of statistical mechanics and kinetic theory:**
   - Particle’s distribution function, Liouville equation, entropy, ensembles; Kinetic theory; Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   - Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. **Basics of the Lattice Boltzmann Method and Simulations:**
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. **Hands on:**
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. **Practical issues of LBM for fluid dynamics simulations:**
   - Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. **Microflow:**
   - Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. **Advanced lattice Boltzmann methods:**
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. **Introduction to LB models beyond hydrodynamics:**
   - Relativistic fluid dynamics; flows with phase transitions.

**Lecture notes**

Lecture notes on the theoretical parts of the course will be made available.

**Prerequisites / notice**

The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Type</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0215-00L</td>
<td><strong>Fundamentals of Acoustics</strong></td>
<td>4</td>
<td>W</td>
<td>N. Noiray, B. Van Damme</td>
</tr>
<tr>
<td>151-0216-00L</td>
<td><strong>Wind Energy</strong></td>
<td>4</td>
<td>W</td>
<td>N. Chokani</td>
</tr>
<tr>
<td>151-0221-00L</td>
<td><strong>Introduction to Modeling and Optimization of Sustainable Energy Systems</strong></td>
<td>4</td>
<td>W</td>
<td>G. Sansavini, A. Bardow</td>
</tr>
</tbody>
</table>

**Abstract**

- This course provides an introduction to acoustics. It focusses on fundamental phenomena of airborne and structure-borne sound waves.
- The lecture combines theoretical principles with practical insights and interpretations.

**Objective**

This course is proposed for Master and PhD students interested in getting knowledge in acoustics. Students will be able to understand, describe analytically and interpret sound generation, absorption and propagation.

**Content**

First, magnitudes characterizing sound propagation are reviewed and the constitutive equations for acoustics are derived. Then the different types of sources (monopole/dipole/quadrupole, punctual, non-compact) are introduced and linked to the noise generated by turbulent flows, coherent vortical structures or fluctuating heat release. The scattering of sound by rigid bodies is given in basic configurations. Analytical, experimental and numerical methods used to analyze sound in ducts and rooms are presented (Green functions, Galerkin expansions, Helmholz solvers).

The second part covers elastic wave phenomena, such as dispersion and vibration modes, in infinite and finite structures.

**Lecture notes**

Handouts will be distributed during the class.

**Literature**

Books will be recommended for each chapter.
151-0227-00L Basics of Air Transport (Aviation I) W 4 credits 3G P. Wild

Abstract
In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aeronautics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation. The program is taught in English and we provide 11 different experts/lecturers.

Objective
The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport.

Content
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

Preparation materials & slides are provided prior to each class

Lecture notes
The lecture is planned as class teaching.

Literature
The lecture will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

Prerequisites / notice
The lecture is planned as class teaching.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork not assessed
Customer Orientation assessed
Leadership and Responsibility not assessed
Sensitivity to Diversity assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed

151-0251-00L Principles, Efficiency Optimization and Future Applications of IC Engines W 4 credits 2V+1U Y. Wright, P. Soltic

Abstract

Objective
The students get familiar with operating characteristics and efficiency maximization methods of IC engines for propulsion and decentralized electricity (and heat) generation. To this end, they learn about simulation methods and related experimental techniques for performance assessment in a combination of lectures and exercises.

Content
This course aims at introducing the students to the working principles and efficiency optimization methods for Internal Combustion (IC) engines which are expected to continue to play a very important role in transportation (long-haul heavy duty, marine) and decentralized combined heat and power generation. Following an overview of different applications and powertrains, the course will focus on the following topics: First, a generic overview of the history of IC-Engines is given, and the basic dimensions and specific engine-relevant terminology are introduced. Next, operating maps for different duty cycles are discussed, highlighting the benefits of individual powertrain configurations for different usage scenarios. The high-pressure thermodynamic process and combustion-induced heat release are analyzed in detail and the design of the combustion processes is discussed in view of further optimization of the energy conversion efficiency. The concept of boosting, its challenges and potential are also presented. In addition, flow field characteristics, convective and radiative heat transfer and combustion modes (Otto, Diesel and “multi-mode” cycles) will be discussed along with possible simulation methods. The course consists of lectures combined with exercises. In addition, several invited guest talks will be held by representatives from Swiss industrial companies active in this field. Provided the pandemic measures allow, visits to different engine test facilities are further envisioned.

Literature

Prerequisites / notice
This course provides background for the course 151-0254-00L “Environmental Aspects of Future Mobility” held in the Spring Semester, where the focus is on emission formation and minimization, exhaust gas after treatment systems and potentials of future synthetic/e-fuels in IC engines; all given in the broader context of a future mobility/transport options (battery electric, hybrids, fuel cells etc.) and transformation pathways towards sustainability.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed

151-0386-00L Aeroelasticity W 4 credits 2V+1U M. Righi

Abstract
Introduction to the basics and methods of Aeroelasticity. An overview of the main static and dynamic phenomena arising from the interaction between structural and aeroelastic loads.

Objective
The course will provide a basic physical understanding of flow-structure interaction. You will get to know the most important phenomena in the static and dynamic aeroelasticity, as well as a presentation of the most relevant analytical and numerical prediction methods.
Introduction to steady and unsteady thin airfoil theory, extension to three dimension wing aerodynamics, strip theory, overview of numerical methods available (panel methods, CFD).

Introduction to unsteady aerodynamics (theory): Theodorsen and Wagner functions. Unsteady aerodynamics observed from numerical experiments (CFD). Generation of simplified mathematical models.

Presentation of steady aeroelasticity: equations of equilibrium for the typical section, aeroelastic deformation, effectiveness of the aeroelastic system, stability (definition), divergence condition, role played by a control surface, control effectiveness, sweep angle, aeroelastic tailoring of bending-torsion coupling. Ritz model to model beams, use of FEM, modal condensation, choice of generalized coordinates.


Numerical aeroelasticity (Test Cases extracted from the latest AIAA Aeroelastic Prediction Workshops).

Aerelasticity of modern aircraft: assessment of the effects induced by the control surfaces and control systems (Aeroservoelasticity), active controlled aircraft, flutter-suppression systems, certification (EASA, FAA).

Planning and execution of Wind Tunnel experiments with aeroelastic models. Live-execution of an experiment in the WT of the ETH.

Brief presentation of non-linear phenomena like Limit-Cycle Oscillations (LCO)

Lecture notes
A script in English language is available.

Literature
Bispinehoff Ashley, Aeroelasticity
Abbott, Theory of Wing sections,

151-0709-00L Stochastic Methods for Engineers and Natural Scientists

Abstract
The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent and subsurface flows. Moreover, mathematical techniques are presented that are used to quantify uncertainty in various engineering applications.

Objective
By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover, you should be able to develop basic stochastic models of such systems.

Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation

All topics are illustrated with engineering applications.

Lecture notes
Detailed lecture notes will be provided.

Literature
Some textbooks related to the material covered in the course:

151-0851-00L Robot Dynamics

Abstract
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

Objective
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content
The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Prerequisites / notice
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

151-0917-00L Mass Transfer

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.
The objective of the lecture is to expound the engineering design approach of important elements in chemical plant design.

3G

The lecture slides will be distributed.

Handouts during the class

Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.

The class covers separation techniques that are central in the purification and downstream processing of chemicals and bio-pharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

Preparations

The students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0927-00L

Rate-Controlled Separations in Fine Chemistry

W 6 credits 3V+1U M. Mazzotti, V. Becattini

Objective

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

Content

The class covers separation techniques that are central in the purification and downstream processing of chemicals and bio-pharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

Lecture notes

Handouts during the class

Literature

Recommendations for text books will be covered in the class

Prerequisites / notice

Requirements (recommended, not mandatory); Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

Taught competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Techniques and Technologies

Social Competencies

Communication

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Not assessed

Not assessed

Not assessed

Not assessed

Not assessed

Not assessed

Not assessed

151-0951-00L

Process Design and Safety

W 4 credits 2V+1U F. Trachsel, C. Hutter

Abstract

The lecture Process Design and Safty deals with the fundamentals of project management, scale-up, dimensioning and safety of chemical process equipment and plants.

Objective

The objective of the lecture is to expound the engineering design approach of important elements in chemical plant design.

Content

Fundamentals in Chemical engineering Design;

Project Management,

Cost estimate,

Materials and Corrosion,

Piping and Armatures,

Pumps,

Reactors and Scale-up,

Safety of chemical processes,

Patents

Lecture notes

The lecture slides will be distributed.

Literature


Prerequisites / notice

A 1-day excursion including a visit of a chemical plant will be part of the lecture.

151-1116-00L

Introduction to Aircraft and Car Aerodynamics

W 4 credits 3G M. Immer, F. Schröder

Abstract

Aircraft aerodynamics: Atmosphere; aerodynamic forces (lift, drag); thrust.


Objective

An introduction to the basic principles and interrelationships of aircraft and automotive aerodynamics.

To understand the basic relations of the origin of aerodynamic forces (e lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components.

Illustration of the intrinsic problems and results using examples.

Using experimental and theoretical methods to illustrate possibilities and limits.

Content

Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force: profile, wings, Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.


Lecture notes

Preparation materials & slides are provided prior to each class.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1564 of 2345
Literature

Aircraft Aerodynamics:
- Schlichting,H und Truckenbrodt, E: Aerodynamik des Flugzeuges (Bd I und II), Springer Verlag, 1960
- Hoerner, S.F.: Fluid Dynamic Lift, Hoerner Fluid Dynamics, 1975

Vehicle Aerodynamics

Abstract

Structural Reliability and Risk Analysis
W 3 credits 2G  S. Marelli

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

Lecture notes

Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

Literature


S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-v0.92-107.

Prerequisites / notice

Basic course on probability theory and statistics

Information Systems for Engineers
W 4 credits 2V+1U  G. Fourny

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

- Lecture material (slides).

It is not required to buy the book, as the library has it

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

636-0507-00L Synthetic Biology II W 8 credits 4A S. Panke, Y. Benenson, J. Stelling

Does not take place this semester.
Students in the MSc Biotechnology (Programme Regulations 2017) may select Synthetic Biology II instead of the Research Project 1.

Abstract

7 months biological design project, during which the students are required to give presentations on advanced topics in synthetic biology (specifically genetic circuit design) and then select their own biological system to design. The system is subsequently modeled, analyzed, and experimentally implemented. Results are presented at an international student competition at the MIT (Cambridge).

Objective

The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.

Content

Presentations on advanced synthetic biology topics (eg genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence, (DNA synthesis external) implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (www.igem.org).

Lecture notes

Handouts during course
Mechanics, Materials, Structures

The courses listed in this category “Core Courses” are recommended. Alternative courses can be chosen in agreement with the tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0107-20L</td>
<td>High Performance Computing for Science and Engineering (HPCSE) I</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
</tbody>
</table>

Abstract
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

Objective
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

Content
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/
Class notes, handouts

Literature
• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
• Lecture notes

Prerequisites / notice
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

Fundamentals of Acoustics

Note: The previous course title until HS21 “Engineering Acoustics I”

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<tr>
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<tr>
<td>151-0215-00L</td>
<td>Fundamentals of Acoustics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>N. Noiray, B. Van Damme</td>
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</table>

Abstract
This course provides an introduction to acoustics. It focusses on fundamental phenomena of airborne and structure-borne sound waves. The lecture combines theoretical principles with practical insights and interpretations.

Objective
This course is proposed for Master and PhD students interested in getting knowledge in acoustics. Students will be able to understand, describe analytically and interpret sound generation, absorption and propagation.

Content
First, magnitudes characterizing sound propagation are reviewed and the constitutive equations for acoustics are derived. Then the different types of sources (monopole/dipole/quadrupole, punctual, non-compact) are introduced and linked to the noise generated by turbulent flows, coherent vortical structures or fluctuating heat release. The scattering of sound by rigid bodies is given in basic configurations. Analytical, experimental and numerical methods used to analyze sound in ducts and rooms are presented (Green functions, Galerkin expansions, Helmholtz solvers). The second part covers elastic wave phenomena, such as dispersion and vibration modes, in infinite and finite structures.

Lecture notes
Handouts will be distributed during the class

Literature
Books will be recommended for each chapter

Visualization, Simulation and Interaction - Virtual Reality II

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<th>Number</th>
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<td>Visualization, Simulation and Interaction - Virtual Reality II</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Kunz</td>
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</table>

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today’s VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; interaction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

Lecture notes
The handout is available in German and English

Prerequisites / notice
Prerequisites:
“Visualization, Simulation and Interaction - Virtual Reality I” is recommended, but not mandatory.

Didactical concept:
The course consists of lectures and exercises.
### Taught competencies

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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#### 151-0353-00L Mechanics of Composite Materials

**Abstract**
Focus is on laminated fibre reinforced polymer composites. The course treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

**Objective**
To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures made from fibre reinforced polymer composites, including elastic behaviour, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

**Content**
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Variable stiffness structures

**Lecture notes**
Script, handouts, exercises and additional material are available in PDF-format on the CMASLab webpage resp on moodle.

**Literature**
The lecture material is covered by the script and further literature is referenced in there.

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<td>Project Management</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
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#### 151-0368-00L Aeroelasticity

**Abstract**
Introduction to the basics and methods of Aeroelasticity. An overview of the main static and dynamic phenomena arising from the interaction between structural and aerodynamic loads.

**Objective**
The course will provide a basic physical understanding of flow-structure interaction. You will get to know the most important phenomena in the static and dynamic aeroelasticity, as well as a presentation of the most relevant analytical and numerical prediction methods.

**Content**
Introduction to steady and unsteady thin airfoil theory, extension to three dimension wing aerodynamics, strip theory, overview of numerical methods available (panel methods, CFD).

Introduction to unsteady aerodynamics (theory): Theodorsen and Wagner functions. Unsteady aerodynamics observed from numerical experiments (CFD). Generation of simplified mathematical models.

Presentation of steady aeroelasticity: equations of equilibrium for the typical section, aeroelastic deformation, effectiveness of the aeroelastic system, stability (definition), divergence condition, role played by a control surface, control effectiveness, sweep angle, aeroelastic tailoring of bending-torsion coupling. Ritz model to model beams, use of FEM, modal condensation, choice of generalized coordinates.


Numerical aeroelasticity (Test Cases extracted from the latest AIAA Aeroelastic Prediction Workshops).

Aeroelasticity of modern aircraft: assessment of the effects induced by the control surfaces and control systems (Aeroservoelasticity), active controlled aircraft, flutter-suppression systems, certification (EASA, FAA).

Planning and execution of Wind Tunnel experiments with aeroelastic models. Live-execution of an experiment in the WT of the ETH.

**Lecture notes**
A script in English language is available.

**Literature**
Bispelinghoff Ashley, Aeroelasticity
Abbott, Theory of Wing sections,
Acoustics in Fluid Media: From Robotics to Additive Manufacturing

Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

Lecture notes / notice

Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

Taught competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1569 of 2345
Adaptive Materials for Structural Applications

Prerequisites / notice

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecture Time</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>151-0550-00L</td>
<td>Adaptive Materials for Structural Applications</td>
<td>4</td>
<td>3G</td>
<td>A. Bergamini</td>
</tr>
</tbody>
</table>

Content

- Basic knowledge of optics and interferometry as taught in basic physics courses are advantageous.
- The lecture introduces optical methods to assess engineering structures and material parameters, and to validate numerical simulations. The techniques rely on cameras, most notably semiconductor sensors as well as micro-bolometers, and make use of incoherent white light and coherent light sources such as halogen lamps and lasers, respectively. The topics of the lecture include:
  - Optics and imaging
  - Digital Image Correlation in 2D and 3D
  - Fringe Projection and structured light techniques
  - Diffraction and holography
  - Speckle pattern interferometry
  - Terahertz (THz) techniques
  - Thin film processes and 3D printing
  - Photoelasticity and ellipsometry
  - Thermoelastic Stress Analysis
  - Validation of numerical models

We show how the methods are applied to microsystems as well as large engineering structures. In addition, time-resolved measurements in the context of modal analysis and dynamic events are explained.

The lecture includes two afternoons at Empa, where the students will gain first-hand experience with optical methods in the laboratory. Depending on availability of the equipment and the interest of the students, these hands-on classes may include e.g. Digital Image Correlation, speckle pattern interferometry, THz holography, Thermal Stress Analysis, ellipsometry and fringe projection.

Lecture notes

Copies of the presented slides will be made available in advance through ILIAS. These slide copies allow the student to add own notes and explanations given during the lecture. We will strive to provide summary scripts for each lesson. Each lecture includes a set of exercises. Standard solutions for the exercises will be posted after the homework due dates.

Finally, you will be invited to a private blog which shall stimulate the discussion of the lecture content and the exercises.

Exam: two-hour written exam in English.

Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

Notice

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

Autumn Semester 2022
Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated, also with laboratory experiments where possible.

The study of adaptive materials covers topics that range from chemistry to theoretical mechanics. The aim of this course is to convey knowledge about adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions.

Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion


Thermo-mechanical coupling: Shape memory alloys / polymers

Electromechanical coupling(1): DEA, EBL, electro rheological fluids

Shape control / morphing: Use, requirements, challenges

Morphing applications of variable stiffness structures: Lab work

Electromechanical coupling (2): Piezoelectric, electrostrictive effect

Vibration Reduction: Measurement, passive, semi-active (active) damping methods

Vibration reduction applications of piezoelectric materials: Lab work

Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials

Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...

Lecture notes (manuscript and handouts) will be provided

151-0573-00L System Modeling

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Analytical Competencies</th>
<th>Problem-solving</th>
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<tbody>
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<td>Method-specific Competencies</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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</table>

151-0655-00L Skills for Creativity and Innovation

<table>
<thead>
<tr>
<th>Skills for Creativity and Innovation</th>
<th>W 4 credits</th>
<th>4G I. Goller, C. Kobe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td></td>
<td>This lecture aims to enhance the knowledge and competency of students regarding their innovation capability. An overview on prerequisites of and different skills for creativity and innovation in individual &amp; team settings is given. The focus of this lecture is clearly on building competencies - not just acquiring knowledge.</td>
</tr>
</tbody>
</table>
Objective
- Basic knowledge about creativity and skills
- Knowledge about individual prerequisites for creativity
- Development of individual skills for creativity
- Knowledge about teams
- Development of team-oriented skills for creativity
- Knowledge and know-how about transfer to idea generation teams

Content
Basic knowledge about creativity and skills:
- Introduction into creativity & innovation: definitions and models

Knowledge about individual prerequisites for creativity:
- Personality, motivation, intelligence

Development of individual skills for creativity:
- Focus on creativity as problem analysis & solving
- Individual skills in theoretical models
- Individual competencies: exercises and reflection

Knowledge about teams:
- Definitions and models
- Roles in innovation processes

Development of team-oriented skills for creativity:
- Idea generation and development in teams
- Cooperation & communication in innovation teams

Knowledge and know-how about transfer to idea generation teams:
- Self-reflection & development planning
- Methods of knowledge transfer

Lecture notes
Slides, script and other documents will be distributed via moodle.ethz.ch (access only for students registered to this course)

Literature
As well as material handed out in the lecture

151-0703-00L Operational Simulation of Production Lines W 4 credits 2V+1U P. Acél
Abstract
The students learn the application of the event-driven and computer-based simulation for layout and operational improvement of production facilities by means of practical examples. The simulation provides an essential basis for digital twins in Industry 4.0.

Objective
The students learn the right use of (Who? When? How?) of the event-driven and computer-based simulation in the illustration of the operating procedures and the production facilities. The simulation is an important basis for creating a digital twin in the context of Industry 4.0.

Operating simulation in the productions, logistic and scheduling will be shown by means of practical examples. The students should make their first experiences in the use of computer-based simulation.

Content
- Application and application areas of the event-driven simulation
- Simulation in the context of Industry 4.0 (digital twin)
- EXEMPLARY application of a software tool (Technomatrix-Simulation-Software)
- Internal organisation and functionality of simulation tools
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting

The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example.

Lecture notes
Will be sent by email before the lecture (pdf)

Literature
A bibliography will be given during the lectures.

Prerequisites / notice
Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (MAVT, MTEC).

151-0705-00L Manufacturing I W 4 credits 2V+2U K. Wegener, M. Wiessner
Abstract

Objective
Deepened discussion on the machining processes and their optimisation. Outlook on additional areas such as NC-Technique, dynamics of processes and machines, chatter as well as process monitoring.

Content
Deepened insight in the machining processes and their optimisation, chip removal by undefined cutting edge such as grinding, honing and lapping, machining processes without cutting edges such as EDM, ECM, outlook on additional areas as NC-technique, machine- and process dynamics including chatter and process monitoring

Lecture notes
yes

Prerequisites / notice
Prerequisites: Recommendation: Lecture 151-0700-00L Manufacturing elective course in the 4th semester.
Language: Help for English speaking students on request as well as english translations of the slides shown.
Understanding of the complexity of the assembly process as well as its meaning as success and cost factor. The assembly with the different aspects of adding, moving, adjusting, controlling parts etc. Adding techniques; solvable and unsolvable connections. Assembly

plants. Coating techniques and their tasks, in particular corrosion protection.

To understand assembly in its full complexity and its paramount importance regarding cost and financial success. An introduction into a choice of selected joining and coating techniques.

Assembly as combination of several classes of action like, e.g., joining, handling, fine adjustments, etc. Techniques for joining objects temporarily or permanently. Assembly systems. Coating processes and their specific applications, with particular emphasis on corrosion protection.

Lecture notes are handed out during the individual lessons (CHF 20.-).

Knowledge about the value added process sequence for electronics manufacturing, planning of electric and electronic product as well as provided about electronic functional units assembled from these electronic components, on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electronic on a wafer as well as recycling.

Nothing works without electronics! Typical products in mechanical engineering such as machine tools, as well as any kind of vehicle contain a significant amount of electric or electronic components of more than 60%. Thus, it is important to master the value added process sequence for electric and electronic components.

The lecture follows the value added process sequence of electric and electronic components. It contains: Development of electric and electronic circuits, design of electronic circuits on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electronic on a wafer as well as recycling.

The lecture concludes with an excursion to a large manufacturing company. Here, students can the see the application and realization of the manufacturing of electric and electronic devices.

Lecture notes are handed out during the individual lessons (CHF 20.-).

The lecture is partly given by experts from industry.

Recommended to the focus production engineering.

Majority of lecturers from the industry.

Documents are provided during the course. English handouts available on request.

Help for English speaking students on request.

Parts of the lecture are held in english.

The lecture concludes with an excursion to a large manufacturing company. Here, students can the see the application and realization of the manufacturing of electric and electronic devices.

The lecture is partly given by experts from industry.

It is supplemented by an excursion to one of the industry partners.
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<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
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**151-0725-00L Exciting Leadership in a Thrilling Real Business World**

**W 4 credits 3G A. Halbleib**

**Abstract**
What is leadership in a real world? What are the preconditions of personal leadership? What is the differences between Leadership and Management? What is the price to be payed to be a Leader? What are the core competences of a Leader? How to become an inspiring Leader? How to experience exciting leadership in a thrilled real business world.

**Objective**
The objective of this course is to understand the impact of Leadership and to learn based on longterm international leadership experiences very practicale competences and skills needed to be a leader.

**Content**
Definitions and methodes what leadership is about based on real industrial examples. Levels of Leadership. Conflicts, challenges and risks of Leaders. Competences of a leader such as: decision making processes, communication, emotional intelligence, change processes and understanding of people behaviours.

**Lecture notes**
Yes, always after lecture via mail.

**Literature**
Not mandatory, but to be recommended: "The Effective Executive" from Peter Drucker, Verlag Vahlen; ISBN 978 3 8006 46715 from 2014.

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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<tr>
<th>151-0727-00L Colloquium on Manufacturing Technology</th>
<th>W 4 credits 2.5K K. Wegener, A. Kunz</th>
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**Abstract**
Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures, by the majority by experts from the industry. The students prepare a summary of the lectures given and prepare themselves on the basis of these lectures and own information search.

**Objective**
Continuous further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

**Content**
Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

**Lecture notes**
- Students must have participated and passed the courses Manufacturing, Production Machines I and Forming Technology III - Forming Processes.
- Further training with specialized lectures and large participation from the industry.

**Language**
Help for English speaking students on request.

<table>
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<tr>
<th>151-0729-00L Welding Technology</th>
<th>W 4 credits 3G K. Wegener</th>
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**Abstract**
The course provides a survey over the mostly used welding technologies and a basic metallurgical understanding for planning and realization of welded joints.

**Objective**
The students will gain the competence and understanding to select welding processes properly, to specify the seam preparation and to predict the achievable welding results.

**Content**
The cours presents in some detail the welding processes gas welding, TIG, MIG/MAG, Fillerwire welding arc welding and laser welding. After the resention of the basics of welding the special properties of the different process technologies are explained and the energy sources and the interaction between the process energy and the material discussed. The metallurgical basics to answer material problems are presented. From this process parameters can then be derived, to achieve the desired seam qualities.

**Lecture notes**
will be distributed accompanying the course progress together with the lecture slides.

**Prerequisites / notice**

<table>
<thead>
<tr>
<th>151-0733-00L Basics and Processes of Metal Forming</th>
<th>W 4 credits 2V+2U M. Bambach</th>
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**Abstract**
The lecture teaches on the basic knowledge of major processes in sheet metal, tube and bulk metal forming technologies. In particular it focuses on fundamental computation methods, which allow a fast assessment of process behaviour and a rough layout. Process-specific states of stress and deformation are analysed and process limits are identified.

**Objective**
Acquaintance with forming processes. Determination of forming processes. Interpretation of forming manufacturing
Content
The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, ro extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.

Lecture notes
da

151-0741-00L
Sustainable Materials
W 2V+2A 4 credits L. Deillon

Abstract
The lecture addresses the issue of sustainability in manufacturing, focussing on materials. The most used materials, their production and transformation into a product are analysed in terms of energy consumption and emissions. Emphasis is then placed on alternative design strategies which reduce the use of materials and innovative processes which lower energy consumption and emissions.

Objective
After this lecture students will be able to:
- Develop a critical thinking of published sustainability data and facts
- Explain where the materials that we use come from, what emissions arise from the different steps of raw material production and product manufacturing
- Determine where significant changes can be brought
- Develop feasible solutions towards a more sustainable use of materials

Content
- Introduction: what is sustainability, which industrial sectors are responsible for the most CO2 (and other) emissions
- The "real" numbers: where to find reliable data and how one can play with the figures
- Basics of life cycle analysis
- CO2 and other emissions
- The most used materials
  - The 5 most used materials today, their key properties and what they are used for
  - Evolution of production, consumption and resources
- Production, recyclability and new processing routes for Al and steel
- Use less material by design
- Re-use of materials & prolonging products life
- Production of cement, new developments & alternatives
- Presentation of students' projects

Lecture notes
Slides distributed and available on Moodle

Literature
References given in the lecture

151-0833-00L
Applied Finite Element Analysis
W 2V+2U 4 credits B. Berisha, D. Mohr

Abstract
Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

Objective
The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:
- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Content
- Introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

Lecture notes
Lecture slides

Literature

151-0917-00L
Mass Transfer
W 2V+2U 4 credits S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content
- Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications

Literature

Prerequisites / notice
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0917-00L
Fatigue and Fracture in Materials and Structures
W 3G 4 credits A. Taras

Abstract
The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

Does not take place this semester.
In this course, the students will learn:
- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

Content

The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainfall analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Linear elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and “Laboratory Competition”. The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- “Laboratory Competition” at Empa: the students with the closest predictions will win the “Empa Laboratory Competition” and will be awarded a prize.

Lecture notes

Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Prerequisites / notice

Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

227-0447-00L  Image Analysis and Computer Vision  W  6 credits  3V+1U  E. Konukoglu, F. Yu

Abstract


Objective

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

Lecture notes

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.
Abstract
Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signaling systems
- Standards
- Availability and safety
- Traffic control and maintenance

Objective
- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content
EST I (Herbstsemester) - Begriffe, Grundlagen, Merkmale

1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrdynamik

2 Vollbahnfahrzeuge:
2.3 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebssysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung

3 Infrastruktur:
3.1 Fahrweg
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen

4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
Betriebszentrale SBB, Zürich Flughafen
Reparatur und Unterhalt, SBB Zürich Altstetten
Fahrzeugfertigung, Stadler Bussnang

Lecture notes
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice
Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

Taught competencies

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| Personal Competencies        |                        |         |

252-0535-00L Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

No lecture notes, but slides will be made available on the course webpage.


The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### Abstract
This course is an introduction to the field of computer graphics. It covers the fundamental concepts of generating photorealistic images from digital representations of 3D scenes. Students learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

### Objective
At the end of the course, students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

### Content
- **Lecture notes:** no
- **Literature:**
  - High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
  - Multiple view geometry in computer vision
  - Physically Based Rendering: From Theory to Implementation

**Prerequisites / notice**
The programming assignments will be in C++. This will not be taught in the class.

### Abstract
This course provides the basics of relational databases from the perspective of the user. We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the database cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logics

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

351-0555-00L Open- and User Innovation

W 3 credits 2G S. Häfliger, S. Spaeth

Abstract

The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.

Objective

The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active lass participation is required.
This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

Implementing solutions: project management, critical path method, quality control feedback loop.

This successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify root causes and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM

Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.
Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.

The course is structured along three main tasks:
1. Finding solutions
2. Implementing solutions
3. Controlling solutions

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models, analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see "Prerequisites").

Objectives
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

376-1177-00L Human Factors I

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

Content
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
- Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
- Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
- Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
- Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces


Selected Journal Articles and Web Links:


Prerequisites / notice

Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

401-0647-00L Introduction to Mathematical Optimization W 5 credits 2V+1U D. Adjiashvili

Objective
- The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature
- Modelling with mathematical optimization: applications of mathematical programming in engineering.
- Information about relevant literature will be given in the lecture.

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

151-0544-00L Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis W 4 credits 3G E. Hosseini

Abstract
- An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective
- The main objectives of this lecture are:
  - Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects).
  - Understanding the importance of material science and metallurgical considerations in MAM.
  - Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology.
  - Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.
Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (steels, Ti6Al4V, Inconel, Al alloys),
- Design for additive manufacturing
- Artificial intelligence for AM

Exercise sessions use COMSOL, ANSYS, ABAQUS packages for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. COMSOL, ANSYS and ABAQUS agreed to support the course by providing licenses for the course attendees and therefore the students can install the packages on their own systems.

Lecture notes
Handouts of the presented slides.

Literature
No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

Prerequisites / notice
A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.

Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

Objective
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scalability. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mindset of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel computing using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/
Class notes, handouts

Literature
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

Prerequisites / notice
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

151-0325-00L Planning and Decision Making for Autonomous Robots | W | 4 credits | 2V+1U | E. Frazzoli |

Abstract
Planning safe and efficient motions for robots in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and ethical/regulated aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

Objective
The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

Content

Lecture notes
Course notes and other education material will be provided for free in an electronic form.

Literature
There is no required textbook, but an excellent reference is Steve Laliville's book on "Planning Algorithms."

Prerequisites / notice
Students should have taken basic courses in optimization, control systems, probability theory, and should be familiar with modern programming languages and practices (e.g., Python, and/or C/C++). Previous exposure to robotic systems is a definite advantage.

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Note: The dates suggest the data is from August 18, 2022.
Introduction to Dynamic Programming and Optimal Control. Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

Topics include
- Review of Bayesian statistics, stochastic systems and Stochastic Optimal Control
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Set-membership identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

Lecture notes
Lecture notes will be provided.

Prerequisites / notice
Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended.

Background in linear algebra and stochastic systems recommended.

Nonlinear Dynamics and Chaos I

Abstract
Basic facts about nonlinear systems: existence, uniqueness, and dependence on initial data.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.

(2) Near equilibrium dynamics: Linear and Lyapunov stability

(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations

(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.

(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

- Exam: two-hour written exam in English.

- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

Dynamic Programming and Optimal Control

Abstract
Introduction to Dynamic Programming and Optimal Control.

Objective
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature

Prerequisites / notice
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Engineering Systems

Abstract
Introduction to current and future engine systems and their control systems

Objective
Introduction to methods of control and optimization of dynamical systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantitative descriptions.

Content
Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.).

Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions.

Lecture notes
Introduction to Modeling and Control of Internal Combustion Engine Systems

Prerequisites / notice
Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups

Vehicle Propulsion Systems

Abstract
Introduction to current and future propulsion systems and the electronic control of their longitudinal behavior

Objective
Introduction to methods of system optimization and controller design for vehicles. Understanding the structure and working principles of conventional and new propulsion systems. Quantitative descriptions of propulsion systems

Content
Understanding of physical phenomena and mathematical models of components and subsystems (manual, automatic and continuously variable transmissions, energy storage systems, electric drive trains, batteries, hybrid systems, fuel cells, road/wheel interaction, automatic braking systems, etc.).

Presentation of mathematical methods, CAE tools and case studies for the model-based design and control of propulsion systems with the goal of minimizing fuel consumption and emissions.

Lecture notes
Introduction to Modeling and Optimization

ISBN: 978-3-642-10774-0

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1584 of 2345
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field. Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Detailed information can be found on the course website
http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischn@ethz.ch) After your reservation has been confirmed please register online at www.mystudies.ethz.ch.
For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers).

Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab. By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

Lecture notes: Slides, script and other documents will be distributed via moodle.ethz.ch (access only for students registered to this course).

Prerequisites / notice: The lecture will be taught in English.
**Medical Technology Innovation - From Concept to Mass Transfer**

Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures, by the majority by experts from the industry. The students prepare a summary of the lectures given and prepare themselves on the basis of these lectures and own information search.

**Prerequisites / Notice**
- Further training with specialized lectures and large participation from the industry.

**Literature**
As well as material handed out in the lecture

**151-0727-00L**
**Colloquium on Manufacturing Technology**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2.5K</th>
<th>K. Wegener, A. Kunz</th>
</tr>
</thead>
</table>

**Abstract**
Continuous further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

**Content**
Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

**Lecture notes**
No script

- Students must have participated and passed the courses Manufacturing, Production Machines I and Forming Technology III - Forming Processes.

**151-0851-00L**
**Robot Dynamics**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>M. Hutter, R. Siegwart</th>
</tr>
</thead>
</table>

**Abstract**
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

**Objective**
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

**Content**
The course consists of three parts: First, we will refresh and deepen the student’s knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

**Prerequisites / Notice**
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

**151-0905-00L**
**Medical Technology Innovation - From Concept to Clinics**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>I. Herrmann</th>
</tr>
</thead>
</table>

**Abstract**
Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

**Objective**
After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution -interdisciplinary team work and effective communication play a key role.

**Literature**
Teaching material will be available on the moodle.

**Taught competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: assessed

- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: assessed
  - Leadership and Responsibility: assessed
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: assessed
  - Negotiation: assessed

- Personal Competencies
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: assessed

**151-0917-00L**
**Mass Transfer**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>S. E. Pratsinis, V. Mavrantzas, C.-J. Stih</th>
</tr>
</thead>
</table>

**Abstract**
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

**Objective**
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

**Content**
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

**Literature**

**Prerequisites / Notice**
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

**151-1116-00L**
**Introduction to Aircraft and Car Aerodynamics**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>M. Immer, F. Schröder</th>
</tr>
</thead>
</table>

**Objective**
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

**Literature**
As well as material handed out in the lecture
### Abstract
Aircraft aerodynamics: Atmosphere; aerodynamic forces (lift, drag); thrust.

### Objective
An introduction to the basic principles and interrelationships of aircraft and automotive aerodynamics.
To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components.
Illustration of the intrinsic problems and results using examples.
Using experimental and theoretical methods to illustrate possibilities and limits.

### Content
Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force: profile, wings. Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.


### Literature
- Schlichting, H. und Truckenbrodt, E: Aerodynamik des Flugzeuges (Bd I und II), Springer Verlag, 1960
- Hoerner, S.F.: Fluid Dynamic Lift, Hoerner Fluid Dynamics, 1975

### 151-9905-00L Applied Compositional Thinking for Engineers II

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
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**Abstract**
This course is an introduction to advanced topics in Applied Category Theory focused on the need of applications. The course favors a computational, constructive, and compositional approach targeted to specific applications in engineering.

**Objective**
In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of the problem and the design of the solution. However, the problem is that the type of math which could be useful to applications is not traditionally taught. Applied Category Theory is a new field of mathematics that could help thinking about compositionality.
However, there exists no easy path for learning it for engineers that is approachable and shows practical applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I), offered in Spring 2021.

This course's goal is not to teach category theory for the sake of it. Rather, we will teach the "compositionality way of thinking"; category theory will be just the means towards it. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.
The course will favor a computational/constructive approach, highlighted even more in the second part of the class: each concept is accompanied by concrete exercises in the programming language Python.

The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.

**Content**
Categories

- Naturality:
  - Natural transformations
  - Adjunctions
  - Traced monoidal categories
- Computation:
  - From mathematical models to algorithms
  - Solving finite co-design problems
- Monads
- Modeling uncertainty

Enriched category theory:
- Profunctors
- Enriched categories
- Negative category theory

Wirings:
- Operads
- Wiring diagrams

Linear logic:
- Linear logic and DP

**Lecture notes**
Slides and notes will be provided.

**Literature**

**Prerequisites / notice**
The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Algebra (sets, posets, relations, semigroups, groups).
3) Python programming.

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in Spring Semester are sufficiently proficient in (1)-(3).
Embedded Systems

Abstract
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

Objective
Understanding specific requirements and problems arising in embedded system applications.

Content
Understanding architectures and components, their hardware-software interfaces, the memory architecture, communication between components, embedded operating systems, real-time scheduling theory, shared resources, low-power and low-energy design as well as hardware architecture synthesis.

Using the formal models and methods in embedded system design in practical applications using the programming language C, the operating system FreeRTOS, a commercial embedded system platform and the associated design environment.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems FreeRTOS, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html.

Lecture notes
Available on the course Moodle platform.

Prerequisites / notice
Prerequisites: Basic knowledge in computer architectures and programming.

Linear System Theory

Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and explaining proofs of properties of linear control systems.

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes
Available on the course Moodle platform.

Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

Subject-specific Competencies
Concepts and Theories

Techniques and Technologies

Analitical Competencies

Problem-solving

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Image Analysis and Computer Vision

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions.
Prerequisites:
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
The course language is English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0517-10L</td>
<td>Fundamentals of Electric Machines</td>
<td>W 6</td>
<td>4G</td>
<td>D. Bortis</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.</td>
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<tr>
<td>Objective</td>
<td>The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.</td>
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</table>
| Content       | - Fundamentals in magnetic circuits and electromechanical energy conversion.  
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).  
- Complex space vector notation, rotating coordinate system (dq-transformation).  
- Loss components in electric machines, scaling laws of electromechanical actuators.  
- Mechanical and thermal modelling. |
| Lecture notes | Lecture notes and associated exercises including correct answers |

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0689-00L</td>
<td>System Identification</td>
<td>W 4</td>
<td>2V+1U</td>
<td>R. Smith</td>
</tr>
<tr>
<td>Abstract</td>
<td>Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.</td>
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<tr>
<td>Objective</td>
<td>To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.</td>
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</tbody>
</table>
| Content       | Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.  
Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.  
Optimal experimental design, Cramer-Rao bounds, input signal design.  
Parametric identification methods. On-line and batch approaches.  
Closed-loop identification strategies. Trade-off between controller performance and information available for identification.  
| Literature    | Additional papers will be available via the course Moodle. |
| Prerequisites / notice | Control systems (227-0216-00L) or equivalent. |

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0920-00L</td>
<td>Seminar in Systems and Control</td>
<td>Z 0</td>
<td>1S</td>
<td>F. Dörfler, R. D'Andrea, E. Frazzoli, M. H. Khammash, J. Lygeros, R. Smith</td>
</tr>
<tr>
<td>Abstract</td>
<td>Current topics in Systems and Control presented mostly by external speakers from academia and industry see above</td>
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<tr>
<td>Objective</td>
<td>see above</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Lecturer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0834-00L</td>
<td>Information Systems for Engineers</td>
<td>W 4</td>
<td>2V+1U</td>
<td>G. Fourny</td>
</tr>
</tbody>
</table>
| Abstract      | This course provides the basics of relational databases from the perspective of the user.  
We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics). |

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1590 of 2345
Objective

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Know and deal with the natural syntax for relational data, CSV.
11. Explain, in the big picture, how a relational database is physically implemented.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

11. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Abstract

The course provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.

Objective

The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context.

Content

The course will introduce students to several methods of analysing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing.

Students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

The course website can be found here:
https://teaching.siplab.org/human_computer_interaction/2022/
Abstract

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice

Solid basic knowledge in statistics, algorithms and programming. The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

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**263-5902-00L Computer Vision**

*8 credits* 3V+1U+3A  M. Pollefeys, S. Tang, F. Yu

**Abstract**

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

**Objective**

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Content**

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

**Prerequisites / notice**

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

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**376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions**

*3 credits* 2V  R. Rienner, O. Lambercy

**Abstract**

Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

**Objective**

Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

**Content**

Introduction, problem definition, overview
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochles Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Literature

Introductory Books:


Selected Journal Articles and Web Links:


VideoTact, ForeThought Development, LLC. http://my.execpc.com/~dwysocki/videotac.html

Prerequisites / notice

Target Group:

Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich

Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

376-1504-00L

Abstract

Physical Human Robot Interaction (pHRI) W 4 credits 2V+2U O. Lambercy

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de- sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.
This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here, salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

### Lecture notes

Will be distributed on Moodle before the lectures.

### Literature


### Prerequisites / notice

The registration is limited to 26 students.

There are 4 credit points for this lecture.

The lecture will be held in English.

The students are expected to have basic control knowledge from previous classes. http://www.relab.ethz.ch/education/courses/phri.html

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### Micro & Nanosystems

The courses listed in this category “Core Courses” are recommended. Alternative courses can be chosen in agreement with the tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0107-20L</td>
<td>High Performance Computing for Science and Engineering (HPCE) I</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the ‘think parallel’ mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/
Class notes, handouts

Literature
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

Prerequisites / notice
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.
The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

<table>
<thead>
<tr>
<th>151-0409-00L</th>
<th>Multiphysics Modeling and Simulation</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>C. I. Roman</th>
</tr>
</thead>
</table>

**Abstract**
This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

**Objective**
As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling.

Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

**Content**
- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

**Lecture notes**
Lecture handouts will be posted online.

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

<table>
<thead>
<tr>
<th>151-0604-00L</th>
<th>Microrobots</th>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>B. Nelson</th>
</tr>
</thead>
</table>

**Abstract**
Microrobots is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**
The objective of this course is to expose students to the fundamental aspects of the emerging field of micro robotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

The lecture will be taught in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecture Hours</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0605-00L</td>
<td>Nanosystems W 4 credits 4G A. Stemmer</td>
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<tr>
<td>Abstract</td>
<td>From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.</td>
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<tr>
<td>Objective</td>
<td>Familiarize students with basic science and engineering principles governing the nano domain. Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.</td>
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<tr>
<td>Content</td>
<td>Topics are treated in 2 blocks: (I) From Quantum to Continuum From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. (II) Interaction Forces on the Micro and Nano Scale Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.</td>
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<table>
<thead>
<tr>
<th>Literature</th>
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<table>
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<tr>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures and Mini-Review presentations: Thursday 10-13</td>
</tr>
<tr>
<td>Homework: Mini-Review (compulsory continuous performance assessment)</td>
</tr>
</tbody>
</table>

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Lecture Hours</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0620-00L</td>
<td>Embedded MEMS Lab W 5 credits 3P C. Hierold, M. Haluska</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access</td>
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<tr>
<td>Objective</td>
<td>Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.</td>
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<tr>
<td>Content</td>
<td>With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out: Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures Packaging and electrical connection of a MEMS device Testing and characterization of the MEMS device Written documentation and evaluation of the entire production, processing and characterization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>The document provides sufficient information for the participants to successfully participate in the course.</td>
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</tbody>
</table>
Prerequisites / notice

Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Danaio, Dual, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or Microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

151-0621-00L Microsystems I: Process Technology and Integration W 6 credits 3V+3U M. Haluska, C. Hierold

Abstract
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).

Objective
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).

Content
- Introduction to Microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific Microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Application of selected technologies will be demonstrated on case studies.

Lecture notes
Handouts (available online)

Literature
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice
Prerequisites: Physics I and II

151-0642-00L Seminar on Micro and Nanosystems Z 0 credits 1S C. Hierold

Abstract
Scientific presentations from the field of Micro- and Nanosystems

Objective
In particular, the seminar addresses students, who are interested in scientific work in the field of Micro- and Nanosystem technologies, or who have started already with it. Respectively, current examples in the research will be discussed.

Content
Current themes in the field of Micro- and Nanosystem technologies using the examples of intern and extern research groups, as well as ongoing themes of study-, diplom- and doctoral thesis will be introduced and discussed. The scope of the seminar is broadened by occasional guest speakers.

Lecture notes
-

Literature
-

Prerequisites / notice
Master of MNS, MAVT, ITET, Physics

151-0913-00L Introduction to Photonics W 4 credits 2V+2U R. Quidant, J. Ortega Arroyo

Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc....). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
Content

I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Anti-reflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts
Literature
Optics (Hecht) - Pearson
Prerequisites / notice
Physics I, Physics II

151-0917-00L Mass Transfer W 4 credits 2V+2U S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature

Prerequisites / notice
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0931-00L Seminar on Particle Technology Z 0 credits 3S S. E. Pratsinis

Abstract
The goal of the lecture is to convey a basic knowledge in the area of PV materials as well as their construction and production processes and to empower the students to apply the knowledge gained to address current problems in research and practice.

Objective
Students attend and give research presentations for the research they plan to do and at the end of the semester they defend their results and answer questions from research scientists. Familiarize the students with the latest in this field.

252-0834-00L Information Systems for Engineers W 4 credits 2V+1U G. Fourny

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1598 of 2345
Abstract
This course provides the basics of relational databases from the perspective of the user.
We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Objective
This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content
Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature
- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice
For non-CS/DS students only, BSc and MSc
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Bioengineering
The courses listed in this category “Core Courses” are recommended. Alternative courses can be chosen in agreement with the tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</table>

Abstract
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.
**Objective**
With manufacturing processes reaching its limits in terms of transistor density on today's computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the "think parallel" mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

**Content**
1. Hardware and Architecture: Moore's Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn's taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl's Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

**Lecture notes**
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/

**Prerequisites / notice**
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

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**Objective**
151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

A. Kunz

**Abstract**
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

**Objective**
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.

The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

**Content**
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

**Lecture notes**
The handout is available in German and English.

**Prerequisites / notice**
"Visualization, Simulation and Interaction - Virtual Reality I" is recommended, but not mandatory.

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**Objective**
151-8101-00L International Engineering: from Hubris to Hope

E. Tilley, M. Kalina

**Abstract**
Since Europe surrendered their colonial assets, engineers from rich countries have returned to the African continent to address the real and perceived ills that they felt technology could solve. And yet, 70 years on, the promise of technology has largely failed to deliver widespread, substantive improvements in the quality of life. Why?

This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.

**Objective**
After completing the course, participants will be able to
- critique the jargon and terms used by the international community, i.e. "development", "aid", "cooperation", "assistance" "third world" "developing" "global south" "low and middle-income" and justify their own chosen terminology
- recognize the role of racism and white-supremacy in the development of the Aid industry
- understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
- debate the merits of international engineering in popular culture and media
- propose improved SDG indicators that address current shortcomings
- compare the engineering curricula of different countries to identify relative strengths and shortcomings
- explain the inherent biases of academic publishing and its impact on engineering failure
- analyse linkages between the rise of philanthropy and strategic priority areas
- recommend equitable, just funding models to achieve more sustainable outcomes
- formulate a vision for the international engineer of the future

---
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content
- Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature
- Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Analysis into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST other bachelor programs.

Content
- History of BME and the role of biomedical engineers. Ethical issues related to BME.

Lecture notes
- Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

moodle page of the course
Prerequisites / notice
No specific requirements, BUT
ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Taught</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<tr>
<th>Method-specific Competencies</th>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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Social Competencies

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<tr>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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Personal Competencies

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<tr>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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Taught competencies

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<th>Taught</th>
<th>not assessed</th>
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<tbody>
<tr>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<tr>
<td>Social Competencies</td>
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<td>Personal Competencies</td>
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Abstract
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

Objective
During this course the students will:
- learn the basic concepts in biosensing and bioelectronics
- be able to solve typical problems in biosensing and bioelectronics
- learn about the remaining challenges in this field

Content
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA

L2. Fundamentals of quantum and classical noise in measuring biological signals

L3. Biomasurement techniques with photons
L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications

L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes
L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing

L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory

L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes

L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Fick equation, Nernst equation, Donnan equilibrium, Goldman equation)

L10. Channels, amplification, signal gating, and patch clamp Y4

L11. Action potentials and impulse propagation
L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation

L13. Neural networks memory and learning

<table>
<thead>
<tr>
<th>Literature</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)</td>
<td>The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric &amp; magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation &amp; frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).</td>
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</table>
Cell Biophysics

Abstract

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

Prerequisites

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

227-0939-00L  Cell Biophysics W  6 credits  4G  T. Zambelli

Prerequisites / notice

No lecture notes because the two proposed textbooks are more than exhaustive!

Lecture notes

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of

- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology. Students will also learn the principles how biological models are established, and how these models can be tested.

After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.
Cross-Disciplinary Research and Development in Medicine and Engineering

A maximum of 12 medical degree students and 12 (biomedical) engineering degree students can be admitted, their number should be equal.

Abstract
Cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course will bring together engineering students from ETH Zurich and medical students from the University of Zurich to experience the rewards and challenges of such interdisciplinary work in a project based learning environment.

Objective
The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since such differences become the most evident during actual collaborative work, the course is based on a current project in physiology research that combines medicine and engineering. For the engineering students, the specific aims of the course are to:

- Acquire a working understanding of the anatomy and physiology of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the found solutions to a cross-disciplinary audience.

Content
After a general introduction to interdisciplinary communication and detailed background on the collaborative project, the engineering students will team up with medical students to find solutions to a biomedical challenge. In the process, they will be supervised both by lecturers from ETH Zurich and the University of Zurich, receiving coaching customized to the project. The course will end with each team presenting their solution to a cross-disciplinary audience.

Lecture notes
Handouts and relevant literature will be provided.

Prerequisites / notice
IMPORTANT: Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.

Taught competencies

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<td>Project Management</td>
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</table>

| Social Competencies         |                          | assessed |
| Communication              |                          | assessed |
| Cooperation and Teamwork   |                          | assessed |
| Customer Orientation       |                          | assessed |

Information Systems for Engineers

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Objective
This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.
The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on QUAility and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A). Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.
Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brochures, checklists, key articles etc. are uploaded in ILIAS

376-1219-00L Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions
W 3 credits 2V R. Riener, O. Lambercy

Abstract
Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces
## Literature

**Introductory Books:**


**Selected Journal Articles and Web Links:**

- VideoTact, ForeThought Development, LLC. http://my.executec.com/?dwysocki/videotac.html

**Prerequisites / notice**

- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

## Abstract

**Physical Human Robot Interaction (pHRi)**  
4 credits  
2V+2U  
O. Lambercy

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1608 of 2345
This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic devices will be demonstrated and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes

Will be distributed on Moodle before the lectures.

Content

This course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Prerequisites / notice

The registration is limited to 50 students.

Abstract

Measurement and modeling of the human movement during daily activities and in a clinical environment.

Objective

The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

Content

This course includes study design, measurement techniques, clinical testing, accessing movement data and anaysis as well as modeling with regards to human movement.

Literature


http://www.relab.ethz.ch/downloads/open-hardware/haptic-paddle.html, by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Lecture notes
A script will be provided.

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

Literature
- Comprehensive Biomaterials, Ducheyne P. et al., 1st Edition, 2011 (available online via ETH library)

Handouts are deposited online (moodle).

Literature:
This course focuses on the design, fabrication, and testing of components produced by additive manufacturing (AM) technologies.

**Engineering Design Optimization**

_G. Fourny, J. Ferchow, K. Shea_

Parallel to the lectures the students design, manufacture and test prototypes in a project in different product development stages.

**Type**

- Design for Additive Manufacturing

**ECTS**

- W 4 credits

**Hours**

- 4G

**Lecturers**

- K. Shea, T. Stankovic

**Abstract**

The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them.

**Objective**

The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.

**Content**

1. Optimization modeling and theory
2. Unconstrained optimization methods
3. Constrained optimization methods - linear and non-linear
4. Direct search methods
5. Stochastic and evolutionary search methods
6. Multi-objective optimization

**Lecture notes**

available on Moodle

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**Design for Additive Manufacturing**

_151-3215-00L_

**Number of participants limited to 60**

**Type**

- W 4 credits

**ECTS**

- 2G

**Lecturers**

- M. Meboldt, J. Ferchow

**Abstract**

This course focuses on the design, fabrication, and testing of components produced by additive manufacturing (AM) technologies. The course includes a project based on a real-world problem in which students design, fabricate and iteratively optimize functional AM parts using an appropriate AM technology.

**Objective**

In this course fundamental knowledge of Design for Additive Manufacturing (AM). The course will prepare the students to:

- Apply fundamental AM processes (metal and plastics)
- Apply the AM design guidelines
- Adopt AM in an industrial environment
- Apply design tools and methods in AM
- Create an added value of AM
- Work in a project-based product development team

**Content**

Parallel to the lectures the students design, manufacture and test prototypes in a project in different product development stages. The course is addressing the following topics:

- State of the art AM Processes for metal and plastics (LPBF, BJ, MJF, SLS, FDM)
- Design guidelines in AM
- Industrial adoption of AM
- Value creation and business models for AM
- Design tools and methods for AM
- Quality management in AM
- Industry cases of AM applications
- Problem solving and creativity
- Agile Development

**Literature**

Christoph Klahn; Mirko Meboldt: Entwicklung und Konstruktion für die Additive Fertigung - Grundlagen und Methoden für den Einsatz in industriellen Endkundenprodukten

_Vogel Business Media, Würzburg_

ISBN: 978-3-8343-3395-7

Ian Gibson; David Rosen; Brent Stucker: Additive manufacturing technologies - 3D printing, rapid prototyping, and direct digital manufacturing

_Springer, New York_

ISBN: 978-1-4939-2112-6

**Prerequisites / notice**

This course is for master's students.

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchow@ethz.ch).

The successful completion of the course requires active participation in the project, the lecture and the oral exam.

**Final grades**

Based on the performance in the projects, the oral examination and the participation in the lecture.

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**Information Systems for Engineers**

_252-0834-00L_

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

**Abstract**

This course covers fundamentals of relational databases from the perspective of the user.

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**ECTS**

- 4 credits

**Hours**

- 2V+1U

**Lecturers**

- G. Fourny

**Prerequisites / notice**

This course is for master's students.

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchow@ethz.ch).

The successful completion of the course requires active participation in the project, the lecture and the oral exam.

**Final grades**

Based on the performance in the projects, the oral examination and the participation in the lecture.
Objective

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

- Lecture material (slides).

Prerequisites / notice

For non-CS/DS students only, BSc and MSc.

Elementary knowledge of set theory and logic.

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python.

Lit: Multidisciplinary Courses

The students are free to choose individually from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1002-00L</td>
<td>Semester Project Mechanical Engineering Only for Mechanical Engineering MSc.</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master’s program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.
Objective

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program.

### Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>8 credits</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

**Abstract**

No registration required via myStudies.

**Objective**

The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

### Science in Perspective

**see Science in Perspective: Type A: Enhancement of Reflection Capability**

**Recommended Science in Perspective (Type B) for D-MAVT**

**see Science in Perspective: Language Courses ETH/UZH**

### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1001-00L</td>
<td>Master's Thesis Mechanical Engineering</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

**Abstract**

Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

**Objective**

The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>406-0173-AAL</td>
<td>Linear Algebra I and II</td>
<td>E-</td>
<td>6 credits</td>
<td>13R</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

**Abstract**

Linear algebra is an indispensable tool of engineering mathematics. The course is an introduction to basic methods and fundamental concepts of linear algebra and its applications to engineering sciences.

**Objective**

After completion of this course, students are able to recognize linear structures and to apply adequate tools from linear algebra in order to solve corresponding problems from theory and applications. In addition, students have a basic knowledge of the software package Matlab.

**Content**


**Reading:**

Gilbert Strang "Introduction to linear algebra", Wellesley-Cambridge Press: Chapters 1-6, 7.1-7.3, 8.1, 8.2, 8.6


**Literature**


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0363-AAL</td>
<td>Analysis III</td>
<td>E-</td>
<td>4 credits</td>
<td>9R</td>
<td>A. lozzi</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.
Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

Content
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling; Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Literature

Prerequisites / notice
Up-to-date information about this course can be found at:
http://www.math.ethz.ch/education/bachelor/lectures/hs2013/other/analysis3_itet

Key for Hours

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings


2S Cognitively Activating Instructions in MINT Subjects

Gender Issues In Education and STEM

M. Berkowitz Biran

This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the participants will be asked to familiarize themselves with the work of teacher researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice

This course is only apt for students who intend to enrol in the programs “Lehrdiplom” or “Didaktisches Zertifikat”. It is about learning in childhood and adolescence.

Number of participants limited to 30.

Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

851-0242-06L Cognitively Activating Instructions in MINT Subjects ■

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice

Für eine reibungslose Semesterplanung wird eine frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin empfohlen.

851-0242-07L Human Intelligence

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

This course is only apt for students who intend to enrol in the programs “Lehrdiplom” or “Didaktisches Zertifikat”. It is about learning in childhood and adolescence.

Lernformen:


Prerequisites / notice

This course is only apt for students who intend to enrol in the programs “Lehrdiplom” or “Didaktisches Zertifikat”. It is about learning in childhood and adolescence.

Number of participants limited to 30.

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract

In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the underrepresentation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

Objective

- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

Content

Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

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Number of participants limited to 30.

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.
Learning (EW 1)"

The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

Objective
- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

851-0242-08L Research Methods in Educational Science W 1 credit 2S C. M. Thurn, T. Braas, P. Edelsbrunner

Number of participants limited to 30

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)"

Abstract

Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

851-0240-20L Coping with Psychosocial Demands of Teaching (EW4 W 2 credits 3S U. Markwalder, S. Maurer, Peteranderl-Rüschhoff

Number of participants limited to 20.

The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.

Abstract

In this class, students will learn concepts and skills for coping with psychosocial demands of teaching

Objective

Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.

1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contexts (e.g. illegal or psychological services).

851-0228-00L Formation of Knowledge in STEM Fields in Primary and Secondary School W 2 credits 2S U. Markwalder

Addresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enroled after successful participation in the course 851-0240-00L "Human Learning (EW1)"

Abstract

The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

Objective

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

Content

Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

Subject Didactics and Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Number Title Type ECTS Hours Lecturers

151-1079-00L Teaching Internship Including Examination Lessons in Mechanical and Process Engineering W 6 credits 13P Q. Lohmeyer

The teaching internship can just be visited if all other courses of TC are completed.

Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

Abstract

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Dokument: schriftliche Vorbereitung für Prüfungslektionen.

Wird von der Praktikumslehrperson bestimmt.

Alle anderen Lehrveranstaltungen des DZ (inkl. der Mentorierten Arbeit) sind erfolgreich abgeschlossen.

### 151-1072-00L Mentored Thesis in Didactics of Mechanical and Process Engineering

**Abstract**
The purpose of the mentored thesis is to bring together the findings from didactics and to expand them by incorporating specific teaching techniques and teaching methods. The thesis can be thematically aligned with the subsequent teaching internship.

**Objective**
The students learn to link theoretical topics from the didactic education with practice-relevant aspects and to articulate the result in written form by means of a suitable task.

**Content**
The choice of the topic and the definition of the contents takes place in agreement between the students and the mentor. The topic must be chosen in such a way that the learning objective described above can be achieved.

**Lecture notes**
A short guideline is available.

**Literature**
The use of suitable literature is part of the assignment.

**Prerequisites / notice**
Prerequisite: Both didactics courses completed.

The work should be completed before the start of the internship.

### 227-0857-00L Subject Didactics I for D-MAVT and D-ITET

**Abstract**
Didactics I focuses on teaching techniques as building blocks of typical lessons. This is done on the basis of the findings of teaching and learning research and their implementation in practice. The aim is the planning and implementation of effective teaching sequences as well as their evaluation and reflection.

**Objective**
- The students can plan, conduct and critically reflect single lessons.
- They orient themselves towards the academic goals and take into account existing knowledge, the professional environment and the ambitions of the students.
- They can apply the basic teaching principles meaningfully in their subject and suitably structure the learning phases.
- They can reduce and present complex technical content such that it is in a form suitable for the students to learn.
- They have considered examples of the common conceptual errors encountered by students

**Content**
- Planning a teaching unit
- Opening a lecture
- Direct Instruction
- Blackboard writing and slide design
- Develop exercises
- Practicing teaching
- Excursion Fachhochschule

**Lecture notes**
Lecture materials are provided via Moodle.

**Prerequisites / notice**
Prerequisite: Educational science course already completed or at the same time.

### Mechanical and Process Engineering TC - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td></td>
<td>Dr</td>
<td></td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Materials Science Bachelor

Bachelor Studies (Programme Regulations 2020)

Basis Courses Part 1

First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0261-G0L</td>
<td>Analysis I</td>
<td>O</td>
<td>8 credits</td>
<td>5V+3U</td>
<td>A. Steiger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Differential and integral calculus for functions of one and several variables; vector analysis; ordinary differential equations of first and of higher order, systems of ordinary differential equations; power series. The mathematical methods are applied in a large number of examples from mechanics, physics and other areas which are basic to engineering.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Introduction to the mathematical foundations of engineering sciences, as far as concerning differential and integral calculus.</td>
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<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>U. Stammbach: Analysis I/I</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Exercises and online quizzes are an important aspect of this course. Attempts at solving these problems will be honored with a bonus on the final grade. See &quot;Performance assessment&quot; for more information.</td>
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</tr>
<tr>
<td>401-0171-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Linear algebra is an indispensable tool of engineering mathematics. The course offers an introduction into the theory with many applications. The new notions are practised in the accompanying exercise classes. The course will be continued as Linear Algebra II.</td>
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<tr>
<td>Objective</td>
<td>Upon completion of this course, students will be able to recognize linear structures, and to solve corresponding problems in theory and in practice.</td>
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<tr>
<td>Content</td>
<td>Systems of linear equations, Gaussian elimination, solution space, matrices, LR decomposition, Determinants, structure of linear spaces, normed vector spaces, inner products, method of least squares, QR decomposition, introduction to MATLAB, applications</td>
<td></td>
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<tr>
<td>* K. Meyberg / P. Vachenauer, Höhere Mathematik 1, Springer 2003</td>
<td></td>
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<tr>
<td>Prerequisites / notice</td>
<td>Active participation in the exercises is part of this course. It is expected, that students submit 3/4 of all exercises for control.</td>
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</tr>
<tr>
<td>327-0112-00L</td>
<td>Chemistry I</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Niederberger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the basics, terms and concepts of general chemistry, their application to questions in material science and their connection to laboratory experiments and projects.</td>
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<tr>
<td>Objective</td>
<td>1) Students can describe the different atomic structures of metals, polymers and ceramics and derive basic material-typical properties.</td>
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<td>2) Students are familiar with the concept of mole and molar mass and can perform stoichiometric calculations.</td>
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<td>3) Students are able to formulate the law of mass action and, with the help of the equilibrium constant, make statements about the position of equilibrium. They understand how a chemical equilibrium reacts to changes in concentration, pressure and temperature and how to apply Le Châtelier's principle.</td>
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<td>4) Students can define oxidation and reduction, determine oxidation numbers, assign reducing and oxidizing agents and calculate redox potentials. They can transfer the basics of redox chemistry to material science processes and applications such as corrosion or batteries.</td>
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<td>5) They can explain the terms acid and base, understand what pH means and they can perform pH calculations. They can describe the meaning of acids and bases using material science examples.</td>
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<tr>
<td>Content</td>
<td>We start the lecture with the question what chemistry has to do with material science. After that, we devote ourselves to the classification and separation of substances. In the next chapter we discuss the atomic structure and the periodic table. After the introduction to stoichiometry, the field of chemistry that deals with the amounts of substances added and formed in chemical reactions, we will cover the concept of chemical equilibrium, where we will learn about the law of mass action, equilibrium constants, solubility product, and also acid-base equilibria. In the final block of the lecture, materials science will once again be in the focus when we discuss redox reactions, electrochemistry and corrosion as well as the influence of chemical bonding on material properties.</td>
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<tr>
<td>Literature</td>
<td>Lecture slides with references to further literature and additional exercises are available on Moodle.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture slides with references to further literature and additional exercises are available on Moodle.</td>
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</tr>
<tr>
<td>402-0050-00L</td>
<td>Physics I</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>D. Rupp</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture covers the basics of classical mechanics.</td>
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<tr>
<td>Objective</td>
<td>The aim of this lecture is to become familiar with the central concepts of classical mechanics, to test and consolidate basic concepts and physical intuition, and to be able to describe and solve problems with applications from everyday life and technology with the tools learned.</td>
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<tr>
<td>Content</td>
<td>- Inertia, equations of motion, Newton's laws, forces and system boundaries</td>
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<tr>
<td></td>
<td>- Energy, impulse, rocket launch</td>
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<td></td>
<td>- Central forces, celestial mechanics</td>
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<td></td>
<td>- Tidal/apparent forces, resting and accelerated reference systems</td>
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<td></td>
<td>- Rotational motion</td>
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<tr>
<td></td>
<td>- Basic properties of deformable bodies</td>
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<td></td>
<td>- Vibrations and resonance phenomena, waves</td>
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<tr>
<td>Lecture notes</td>
<td>A script to the lecture is provided online.</td>
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<tr>
<td>327-0113-00L</td>
<td>Foundations of Materials Science I</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>L. Isa</td>
</tr>
<tr>
<td>Abstract</td>
<td>The basic physical concepts for the description of materials are taught, partly in self-study, and applied in exercises. Basic atomistic and macroscopic concepts (e.g. phase diagrams, phase transformations, response functions) are introduced through examples. Selected topics are deepened in classroom lectures.</td>
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<tr>
<td>Objective</td>
<td>Students are able to</td>
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<tr>
<td></td>
<td>- name the basic concepts of materials science. (remember, 1)</td>
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<tr>
<td></td>
<td>- describe simple relations between atomic structure and macroscopic properties. (understand, 2)</td>
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<td></td>
<td>- calculate basic material-specific quantities. (apply, 3)</td>
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<td></td>
<td>- read and interpret phase diagrams, material characteristic (e.g. stress-strain) diagrams and Ashby plots (analyse, 4)</td>
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<tr>
<td>Content</td>
<td>Atomic structure</td>
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<tr>
<td></td>
<td>Crystalline structure and defects</td>
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<td></td>
<td>Thermodynamics, phase diagrams and phase transformations</td>
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<td></td>
<td>Diffusion</td>
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<tr>
<td></td>
<td>Mechanical and thermal properties of materials</td>
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</tbody>
</table>
### Literature

- **Main textbook:**
  William D. Callister, Jr., David G. Rethwisch
  *Materials Science and Engineering - An Introduction*

- **Alternatives:**
  Milton Ohring
  *Engineering Materials Science*

  James F. Shackelford
  *Introduction to Materials Science for Engineers*

### Additional First Year Basic Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0111-00L</td>
<td>Projects and Lab Courses I</td>
<td>O</td>
<td>7</td>
<td>7P</td>
<td>M. B. Willeke, L. De Pietro, M. R. Dusseiller, S. Morgenthaler Kobas, T.-B. Schweizer</td>
</tr>
</tbody>
</table>

**Abstract**

Practical introduction to the basics of the scientific method, materials science, physics and chemistry in the form of laboratory experiments and projects, some of which are closely related to the lectures in the first year. Important chemical and physical methods are tested, project work is practiced and the basics of working safely in the laboratory are learned.

**Objective**

- The students
  - keep a laboratory journal independently, completely and appropriately.
  - can evaluate and display measurement data in a targeted manner.
  - are able to write laboratory reports appropriately.
  - know the communicative and rhetorical factors that are decisive for the success of an oral presentation.
  - create effective presentation documents.
  - know the general safety rules and disposal concepts for working in laboratories and apply them practically.
  - proceed correctly in case of accidents and evacuations.
  - learn practically how to fight a fire (fire protection course of the ETH).
  - apply the basic knowledge in analytics, chemistry, physics and materials science acquired in the base year in a practical way.
  - practice carrying out small experiments or small projects independently under supervision.

**Content**

- in the area of scientific work: Keeping lab journals, data analysis, writing reports, presentation techniques, Test preparation and introduction to safe working and behaviour in the lab.
- Lab experiments: Experiments from the fields of synthetic and analytical chemistry and experiments from the fields of physics and materials science, e.g: Mechanical/thermal properties (e.g. modulus of elasticity, fracture mechanics), thermodynamics, colloid chemistry, "particle tracking" with DLS and microscopy, surface technology, "wood, stone and metal" processing, and electrochemistry. Some practical experiments are organized as short projects (two afternoons), e.g. "Building a microscope from a webcam", etc.
- In the projects: Two “reverse engineering” projects with everyday objects: Analysis of construction and materials, functioning in the overall context, life cycle of materials, alternative materials, etc.

**Lecture notes**

Instructions and further information on the individual experiments and projects (objectives, theory, experimental procedure, notes on evaluation) are available on the following website (https://praktikum.mat.ethz.ch).

**Prerequisites / notice**

Special students and auditors need a special permission from the lecturers

### Second Year Basic Courses

#### Examination Blocks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0363-10L</td>
<td>Analysis III</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Iozzi</td>
</tr>
</tbody>
</table>

**Literature**

https://wiki.python.org/moin/BeginnersGuide
Abstract

Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective

Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

Content

Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period \( p=2L \)
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D’Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Lecture notes

Lecture notes by Prof. Dr. Alessandra Iozzi:
https://polybox.ethz.ch/index.php/s/D3K0TayQXvfpCAA

Literature


For reference/complement of the Analysis I/II courses:

Christian Blatter: Ingenieur-Analysis
https://people.math.ethz.ch/~blatter/dlp.html

327-0316-00L Quantum Mechanics for Materials Scientists O 3 credits 2V+1U S. Stepanow

Abstract

Analysis and motivation for the necessity of a theory beyond classical mechanics to describe materials properties. The principles, terminology and concepts of quantum mechanics will be introduced and mathematically represented on the basis of simple problems.

Objective

Give reasons for the necessity of quantum mechanical description of matter and explain experimental observations leading to this description.
Clarification of the term quantum object.
Formulate and solve the Schrödinger equation for simple problems.
Application of the operator formalism for the calculation of observables and the interpretation of physical processes. Interpretation of the wavefunction.
Explain the solution of the hydrogen atom. Derivation of the approach to the solution in the application of symmetries and angular momentum operators.
Give reasons for the electron spin and calculate magnetic moments.
The aim of the course is to enable the students to select and apply the optimal analytical/spectroscopic methods for the identification of polymer types.

The students will be able to recognize different polymer types and associate them with their chemical structure and properties. They will be exposed to different characterization methods such as size exclusion chromatography, mass-spectrometry, nuclear magnetic resonance, and other techniques that are necessary to confirm the successful synthesis and structure of a polymer.

The students will understand the mechanism of selected polymerization methodologies and will discuss how they operate in order to yield materials with enhanced polymeric characteristics.

Particular emphasis is given to qualitative and quantitative analysis of material composition at the atomic/molecular level by mass spectrometry, atomic absorption, vibrational and UV-vis spectroscopy, thermal analysis, nuclear magnetic resonance. The course will include lectures as well as hands-on practical sessions.

### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0312-00L</td>
<td>Materials Synthesis I - Polymers</td>
<td>O</td>
<td>4</td>
<td>4G</td>
<td>A. Anastasi, D. Opris</td>
</tr>
<tr>
<td>327-0315-00L</td>
<td>Statistical Thermodynamics</td>
<td>O</td>
<td>3</td>
<td>3G</td>
<td>A. Gusev, H. C. Öttinger</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1621 of 2345
Introduction into the fundamental relationships between crystal structure, symmetry, and physical properties of solids. Emphasis: group-theoretical introduction into symmetry, discussion of the factors governing the formation of crystal structures, structural dependence of physical properties, fundamentals of experimental techniques probing the crystal structure.

Symmetry and order: symmetry operations and lattices in two and three dimensions, point groups, space groups.

Crystal structures: symmetry and geometrical factors governing the formation of crystal structures; close sphere packings; typical basic crystal structures.

Structure/property relationships: Neumann's principle; examples: piezoelectricity, ferroelectric.

Materials characterization: diffraction techniques.

Objectives
- You are going to address, in groups, problems that are arising or may arise in the context of remaining courses of your studies, that cannot be solved analytically or manually within reasonable amounts of time, but solved computationally with the help of a programming language and computers. Knowledge of a computing language is required.
- Experiments to teach experimental competence using selected examples from polymer chemistry, analytics and physics (e.g. for the storage or conversion of energy), partly closely based on courses.
- Development of a project plan, including modules to be created, milestones to be reached, required input data and its acquisition, tests to be performed, work sharing. The project needs to be documented, and codes saved using a collaborative environment (overleaf). Ideally, several groups attack a similar problem so that their results can be directly compared (concerning speed of execution, clarity etc.)
- Aspects that should be taken into account when developing algorithms or codes are: speed of execution, ease of use, small amount of adjustable parameters.
- Problem-solving, work sharing. The project needs to be documented, and codes saved using a collaborative environment (overleaf). Ideally, several groups attack a similar problem so that their results can be directly compared (concerning speed of execution, clarity etc.)
- Knowledge of a computing language is required. Participants need to create an overleaf account. Detailed information available at https://polyphys.mat.ethz.ch/education/courses/CTL-I.html
- Problem that requires developing algorithms. They make use of existing, or invent novel, computational methods. Aspects that should be taken into account when developing algorithms or codes are: speed of execution, ease of use, small amount of adjustable parameters.
- Knowledge of a computing language is mandatory. Participants need to create an overleaf account. Detailed information available at https://polyphys.mat.ethz.ch/education/courses/CTL-I.html
- Typically, small to medium-sized groups attack a similar problem so that their results can be directly compared (concerning speed of execution, clarity etc.)
- Problem solving, work sharing. The project needs to be documented, and codes saved using a collaborative environment (overleaf). Ideally, several groups attack a similar problem so that their results can be directly compared (concerning speed of execution, clarity etc.)
- Knowledge of a computing language is mandatory. Participants need to create an overleaf account. Detailed information available at https://polyphys.mat.ethz.ch/education/courses/CTL-I.html
- Problem solving, work sharing. The project needs to be documented, and codes saved using a collaborative environment (overleaf). Ideally, several groups attack a similar problem so that their results can be directly compared (concerning speed of execution, clarity etc.)
- Knowledge of a computing language is mandatory. Participants need to create an overleaf account. Detailed information available at https://polyphys.mat.ethz.ch/education/courses/CTL-I.html

Organisation: One hour of lectures per week accompanied by one hour of exercises.

Projects and Applications

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0314-00L</td>
<td>Crystallography</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>T. Lottermoser, M. Fiebig, A. Simonov, T. Weber</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>O</td>
<td></td>
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<tr>
<td></td>
<td>The properties of crystals, which represent a large part of solid materials, are closely related to their structural symmetry. The aim of the lecture crystallography is to convey concepts and mathematical basics of symmetry theory, structure-property relationships, as well as the basic features of structure determination. Simple crystal structure types are discussed.</td>
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<tr>
<td></td>
<td>Content</td>
<td>O</td>
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<tr>
<td></td>
<td>Symmetry and order: symmetry operations and lattices in two and three dimensions, point groups, space groups.</td>
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<tr>
<td></td>
<td>Objective</td>
<td>O</td>
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<tr>
<td></td>
<td>Introduction into the fundamental relationships between crystal structure, symmetry, and physical properties of solids. Emphasis: group-theoretical introduction into symmetry, discussion of the factors governing the formation of crystal structures, structural dependence of physical properties, fundamentals of experimental techniques probing the crystal structure.</td>
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</tr>
<tr>
<td></td>
<td>Literature</td>
<td>O</td>
<td></td>
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<tr>
<td></td>
<td>A script of the lecture until 2014 is available. Script notes for the present lecture will be provided before the start of the lecture.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
<td>O</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Organisation: One hour of lectures per week accompanied by one hour of exercises.</td>
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</tbody>
</table>
This course provides physical foundations to understand the response of different classes of materials to electromagnetic fields, focusing on their electrical, optical, and magnetic properties, and on the basic functioning of devices that exploit such properties. The lectures build on classical and quantum mechanical concepts to provide microscopic understanding and modelling.

Understanding the electronic properties of solids is at the heart of modern society and technology. The aim of this course is to provide fundamental concepts that allow one to relate the electronic structure of different types of materials to their electrical, optical, and magnetic behavior. Beyond fundamental curiosity, such level of understanding is required in order to develop and appropriately describe new classes of materials for future technology applications. By the end of the course the student should have developed a semi-quantitative understanding of basic concepts in solid state physics and be able to appreciate the pertinence of different models to the description of specific material properties, including numerical estimates of the relevant parameters. The student should also learn to describe the working principles of a wide range of devices that are built to take advantage of such properties.

### Third Year Basic Courses

#### Individual courses

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>327-0512-00L</td>
<td>Electronic, Optical and Magnetic Properties of Materials</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>P. Gambardella</td>
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</tbody>
</table>

### Content

#### Abstract

This course provides physical foundations to understand the response of different classes of materials to electromagnetic fields, focusing on their electrical, optical, and magnetic properties, and on the basic functioning of devices that exploit such properties. The lectures build on classical and quantum mechanical concepts to provide microscopic understanding and modelling.

#### Objective

To provide physical concepts for the understanding of material properties as well as the functioning of basic electronic, photonic, and magnetic devices.

- Understanding the electronic properties of solids is at the heart of modern society and technology. The aim of this course is to provide fundamental concepts that allow one to relate the electronic structure of different types of materials to their electrical, optical, and magnetic behavior. Beyond fundamental curiosity, such level of understanding is required in order to develop and appropriately describe new classes of materials for future technology applications. By the end of the course the student should have developed a semi-quantitative understanding of basic concepts in solid state physics and be able to appreciate the pertinence of different models to the description of specific material properties, including numerical estimates of the relevant parameters. The student should also learn to describe the working principles of a wide range of devices that are built to take advantage of such properties.

#### Content

##### PART I: The electronic structure of metals, semiconductors, and insulators

Revision of classical concepts: electric fields and currents, Ohm’s and Drude’s model of electrical conductivity, Hall effect, thermoelectric effects.

Revision of quantum mechanical concepts: Electron bands, Fermi statistics, Fermi energy and Fermi surface, density of states in k-space and as a function of energy.

##### PART II: Semiconductors: concepts and devices


##### PART III: Dielectric properties of insulators


##### PART IV: Interaction of electromagnetic waves with matter

The electromagnetic (EM) spectrum. Electromagnetic waves in vacuum; Energy, momentum, and angular momentum of EM waves; Sources of EM radiation; EM waves in matter. The refractive index. Transmission, Reflection, and Refraction from a microscopic point of view. Optical anisotropy, Optical activity, Dichroism. Optical properties of crystalline insulators and semiconductors, glasses, and metals.

##### PART V: Photonic devices

Photodiodes, photovoltaic cells, light emitting devices (LEDs), Laser diodes, displays, optical fibers.

##### PART VI: Magnetism


### Literature

- C. Kittel, Introduction to Solid State Physics (Wiley, 2005), also printed in German. General text that covers many arguments from the point of view of condensed matter physics.
- D. A. Neamen, Semiconductor Physics and Devices (McGraw-Hill, 2012), General treatment of semiconductor physics and devices, including both basic and more advanced topics.
- Optics and optical materials: E. Hecht, Optics (Lehrmanns) ; M. Fox, Optical Properties of Solids (Oxford U. Press)
- Photonic Devices: D. A. Neamen (see above); Simon Sze, Physics of Semiconductor Devices (Wiley)

### Prerequisites

- Physik I and II, Materialphysik I and II. The lecture will be given in English. The script will be available in English.
### Taught competencies

#### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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<table>
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<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Type</th>
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<tbody>
<tr>
<td>327-0513-00L</td>
<td>Mechanical Properties</td>
<td>7</td>
<td>O</td>
</tr>
<tr>
<td>327-0515-00L</td>
<td>Thermal and Transport Properties</td>
<td>4</td>
<td>O</td>
</tr>
</tbody>
</table>

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#### Abstract

**327-0513-00L Mechanical Properties**

This course provides the fundamentals for understanding the mechanical properties of different classes of materials. The role played by the nano- and microstructure of the materials, how the mechanical properties are influenced by the composition or processing, as well as which methods can be used to determine material-specific mechanical parameters are examined.

**327-0515-00L Thermal and Transport Properties**

This course will introduce mass transport, heat conduction, charge transport, and flow in viscous liquids, with emphasis on their shared foundation in diffusive processes.

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#### Objective

**327-0513-00L Mechanical Properties**

- The students are able to
  - Apply the interplay of structure and properties in the selection and development of materials.
  - Understand plasticity, crack growth, high temperature properties, corrosion, diffusion, environmental influences, grain growth, fatigue, fracture mechanics across material classes.
  - to adjust mechanical properties in a targeted manner.
  - to select and develop the optimal materials for specific application areas by understanding the temperature-dependent material properties.
  - take measures to increase the service life of materials.
  - to link the similarities and differences of the various classes of materials.
  - understand concepts of material development and apply them to new materials.

**327-0515-00L Thermal and Transport Properties**

- Students will learn how to create models describing transport processes. They will solve the resulting equations both analytically and numerically. They will apply these results to design materials processes and understand real-life experiments. A key takeaway will be the ability to construct simple order-of-magnitude estimates and scaling relationships that can be applied to efficient data analysis and design.
Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Projects and Applications

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>327-0514-00L</td>
<td>Computational Thinking Lab II</td>
<td>O</td>
<td>3</td>
<td>1G+2A</td>
<td>M. Kröger</td>
</tr>
</tbody>
</table>

Abstract

You are going to address, in groups, problems that are arising or may arise in the context of remaining courses of your studies, that cannot be solved analytically or manually within reasonable amounts of time, but solved computationally with the help of a programming language and computers. Knowledge of a computing language is required.

Objective

Participants get used to one or more collaborative tools, work actively in groups. They invent, set up, structure, plan, and attempt solving a problem that requires developing algorithms. They make use of existing, or invent novel, computational methods. Aspects that should be taken into account when developing algorithms or codes are: speed of execution, ease of use, small amount of adjustable parameters.

Content

Development of a project plan, including modules to be created, milestones to be reached, required input data and its acquisition, tests to be performed, work sharing. The project needs to be documented, and codes saved using a collaborative environment (overleaf, github, vscode share or similar). Ideally, several groups attack a similar problem so that their results can be directly compared (concerning speed of execution, algorithms, etc.)

Lecture notes

Information available at https://polyphys.mat.ethz.ch/education/courses/CTL-II.html

Literature


Prerequisites / notice

Participants should have attended part I of this course, or attend part I in parallel. Course information available at https://polyphys.mat.ethz.ch/education/courses/CTL-II.html

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies

- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

327-0511-00L Capstone project

Abstract

Acquisition of independent scientific-technical skills; project management; organization and undertaking of experiments; interpretation, scientifically and technically correct project presentation in oral and written form.

Objective

Acquisition of independent scientific/technical skills; project management; organization and conducting of experiments; interpretation and scientifically/technically correct presentation of projects in oral and written form.

Content

Groups of students (2 or 3 per group) each work on a research project throughout the semester.

Prerequisites / notice

Prerequisite: Successful participation in the “Praktika I - IV” (courses within the material science bachelor study at ETH) or comparable practical lab courses.
Compensatory Courses

Only possible after consultation with the Director of Studies.

Bachelor's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0620-10L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>12</td>
<td>23D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract

Independent scientific project in a D-MATL research group. A written report will be prepared on the scientific studies carried out, as well as on the evaluation and discussion of the results.

Objective

To develop the capability of independently analyzing and addressing scientific problems.

Bachelor Studies (Programme Regulations 2017)

5. Semester

Basic Courses Part 3

Self-study courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>327-0506-01L</td>
<td>Materials Physics II</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Gambardella</td>
</tr>
</tbody>
</table>

Abstract

This course provides physical foundations to understand the response of different classes of materials to electromagnetic fields, focusing on the dielectric and optical properties of materials, and on the basic functioning of devices that exploit such properties, including photodiodes, photovoltaic cells, LEDs, and laser diodes.

Objective

This course aims at giving an understanding of physical phenomena relevant to Materials Science and, vice versa, an understanding of materials that are relevant to tailor the physical properties of electronic and optical devices.

Content

PART I: Introduction to the dielectric properties of matter
- Connection between macroscopic and microscopic polarization. Dielectric breakdown.

PART II: Interaction of electromagnetic waves with matter
- The EM spectrum. Electromagnetic waves in vacuum; Energy, momentum, and angular momentum of EM waves; Sources of EM radiation; EM waves in matter. The refractive index. Transmission, Reflection, and Refraction from a microscopic point of view. Optical anisotropy, Optical activity, Dichroism.

PART III: Optical Materials: Crystalline Insulators and Semiconductors, Glasses, Metals. Photonic devices: Photodiodes, Photovoltaic cells, LEDs, Laser diodes

Lecture notes

Lectures and script will be in English.
Lecture notes can be downloaded at http://www.intermag.mat.ethz.ch/education.html

Literature

- Electromagnetism and dielectric properties: E.M. Purcell and D.J. Morin, Electricity and Magnetism (Cambridge U. Press, 2013)
- Optics and optical materials: E. Hecht, Optics (Lehmanns) ; M. Fox, Optical Properties of Solids (Oxford U. Press)
- Photonic Devices: Simon Sze, Physics of Semiconductor Devices (Wiley)

Prerequisites / notice

Materials Physics I (327-0407-01)

327-0603-00L  | Ceramics II                    | O    | 3    | 2V+1U | A. R. Studart     |

Abstract

Understanding of the electrical, dielectric and magnetic properties of functional ceramics for materials engineers, physicists and electrical engineers. An introduction is given to modern ceramics materials with multiple functions.

Objective

Ceramics II covers the basic principles of functional ceramics such as linear and non-linear dielectrics, semiconductors, ionic and mixed ionic-electronic conductors as well as materials aspects of high temperature superconductors. Examples of applications cover the range from piezo- and pyroelectric materials over sensors and solid oxide fuel cells to superconducting magnets.

At the end of the course, the students should be able to select the chemistry, design the microstructure and devise processing routes to fabricate functional ceramics for electronic, electromechanical, optical and magnetic applications.

Content

- Applications of functional ceramics
- Dielectrics fundamentals & Insulators
- Capacitors & resonators
- Ferroelectricity & piezoelectricity
- Pyroelectricity and thermoelectric ceramics
- Defect chemistry
- Conductors
- Impedance spectroscopy
- Magnetic ceramics
- Superconductors

Literature

- Electroceramics; J.A.Moulson
- Free download of the book in ETH domain is possible following the link: http://www3.interscience.wiley.com/cgi-bin/booktoc/104557643

Principles of Electronic Ceramics; L.L.Hench, J.K.West

327-0606-00L  | Polymers II                    | O    | 3    | 2V+1U | T.-B. Schweizer, T. A. Tervoort |

Abstract

Principles of polymer technology

Objective

To obtain an understanding of the engineering aspects of structure and properties of solid polymers. Influence of polymer processing on properties of solid polymers.

Content

1. Crystallization of semi-crystalline polymers
2. Glass transition of amorphous polymers
3. Mechanical properties of solid polymers
4. Examples of polymer processing
5. Laboratory exercises
### Composites

**Abstract**

Introduction of basic concepts for composites with polymer-, metal-, and ceramic matrix composites; production and properties of composites reinforced with particles, whiskers, short and long fibres; selection criteria, case histories of applications, recycling, future perspectives, and basic concepts for adaptive and functional composites.

**Objective**

Gain an insight into the diversity of opportunities to change the properties of composites, learn about the most important applications and processing techniques.

**Content**

1. **Introduction**
   1.1 What are advanced composites?
   1.2 What are materials by combination?
   1.3 Are composites an idea of today?
   1.4 Delphi foresight
   1.5 Why composites?
   1.6 References for chapter 1

2. **Basic modules**
   2.1 Particles
   2.2 Short fibres including whiskers
   2.3 Long fibres
   2.4 Matrix materials
   2.4.1 Polymers
   2.4.2 Metals
   2.4.3 Ceramics and glasses
   2.5 References for chapter 2

3. **PMC: Polymer Matrix Composites**
   3.1 Historical background
   3.2 Types of PMC-laminates
   3.3 Production, processing and machining operation
   3.4 Mechanics of reinforcement, microstructure, interfaces
   3.5 Failure criteria
   3.6 Fatigue behaviour of a multiply composite
   3.7 Adaptive materials systems
   3.8 References for chapter 3

4. **MMC: Metal matrix composites**
   4.1 Introduction: Definitions, selection criteria und "design"
   4.2 Types von MMCs - examples und typical properties
   4.3 Mechanical and physical properties of MMCs - basics of design, influencing variables and damage mechanisms
   4.4 Production processes
   4.5 Micro structure / interfaces
   4.6 Machining operations for MMC
   4.7 Applications
   4.8 References for chapter 4

5. **CMC: Ceramic Matrix Composites**
   5.1 Introduction and historical background
   5.2 Modes of reinforcement
   5.3 Production processes
   5.4 Mechanisms of reinforcement
   5.5 Micro structure / interfaces
   5.6 Properties
   5.7 Applications
   5.8 Materials testing and quality assurance
   5.9 References for chapter 5

### Metals II

**Abstract**

Introduction to materials selection. Basic knowledge of major metallic materials: aluminium, magnesium, titanium, copper, iron and steel. Selected topics in high temperature materials: nickel and iron-base superalloys, intermetallics and refractory metals.

**Objective**

Introduction to materials selection. Basic knowledge of major metallic materials: aluminium, magnesium, titanium, copper, iron and steel. Selected topics in high temperature materials: nickel and iron-base superalloys, intermetallics and refractory metals.

---

**Lecture notes**

The script will be delivered at the beginning of the semester.

**Literature**

The script is including a comprehensive list of references.

**Prerequisites / notice**

Before each class, students will get a handout or they can be uploaded from the internet. The exercises take place in small groups. It is their goal to deepen knowledge gained in the classes written end of semester examination.
Content

This course is divided into five parts:

A. Materials selection
   Principles of materials properties maps
   Introduction to the 'Materials selector' software package
   Case studies

B. Light metals and alloys
   Aluminium, magnesium, titanium
   Properties and hardening mechanisms
   Case studies in technological applications

C. Copper and its alloys

D. Iron and steel
   The seven pros for steel
   Fine grained steels, heat resistant steels
   Steel and corrosion phenomena
   Selection and application

E. High temperature alloys
   Superalloys: iron, nickel, cobalt
   Intermetallics: properties and application

Lecture notes

Please visit the Moodle-link for this lecture.

Literature

Gottstein, Physikalische Grundlagen der Materialkunde, Springer Verlag
Ashby/Jones, Engineering Materials 1 & 2, Pergamon Press
Ashby, Materials Selection in Mechanical Design, Pergamon Press
Porter/Easterling, Transformations in Metals and Alloys, Chapman & Hall
Bürgel, Handbuch Hochtemperatur-Werkstofftechnik, Vieweg Verlag

Prerequisites / notice

Prerequisites: Metals I

Compensatory Courses

Only possible after consultation with the Director of Studies.

Industrial Internship or Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>327-0001-00L</td>
<td>Industrial Internship</td>
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<td>external organisers</td>
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<td>Only for Materials Science BSc.</td>
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<tr>
<td>Abstract</td>
<td>12 weeks of industrial internship which is completed with a written report.</td>
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<tr>
<td>Objective</td>
<td>The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
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<td>Carrying out outside of D-MATL: Only possible after consultation with the Director of Studies.</td>
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<tr>
<td>Abstract</td>
<td>Project in a research group at ETH or at an University of 12 weeks. The project is completed with a written report.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The main objective of the 12-week research project is to expose bachelor's students to the professional research environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
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Bachelor's Thesis

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<tr>
<td>Abstract</td>
<td>Independent scientific project in a D-MATL research group. A written report will be prepared on the scientific studies carried out, as well as on the evaluation and discussion of the results.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>To develop the capability of independently analyzing and addressing scientific problems.</td>
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<td></td>
</tr>
<tr>
<td>Content</td>
<td>Independent work on a scientific research project. The project will be carried out either for two days per week during the 6th semester or in a block within the first 6 weeks after the 6th semester.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The entire project, including preparation of the report, needs to take place within the allotted time.</td>
<td></td>
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</tbody>
</table>

Science in Perspective

Langmat

<table>
<thead>
<tr>
<th>Science in Perspective</th>
<th>Type A: Enhancement of Reflection Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended Science in Perspective (Type B) for D-MATL</td>
<td></td>
</tr>
</tbody>
</table>

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Materials Science Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>Key for Hours</td>
<td></td>
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<td>--------------</td>
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</tr>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Materials Science Master

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0505-00L</td>
<td>Surfaces, Interfaces and their Applications I</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>N. Spencer, M. P. Heuberger, L. Isa</td>
</tr>
</tbody>
</table>

**Abstract**

After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

**Objective**

To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

**Content**

Introduction to Surface Science
- Physical Structure of Surfaces
- Surface Forces (static and dynamic)
- Adsorbates on Surfaces
- Surface Thermodynamics and Kinetics
- The Solid-Liquid Interface
- Electron Spectroscopy
- Vibrational Spectroscopy on Surfaces
- Scanning Probe Microscopy
- Introduction to Tribology
- Introduction to Corrosion Science

**Lecture notes**

Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

**Literature**

Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455


**Prerequisites / notice**

Chemistry:
- General undergraduate chemistry
- including basic chemical kinetics and thermodynamics

Physics:
- General undergraduate physics
- including basic theory of diffraction and basic knowledge of crystal structures

**Taught competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving

- Personal Competencies
  - Creative Thinking
  - Critical Thinking

| 327-1201-00L | Transport Phenomena I | W Dr | 5 credits | 4G | J. Vermant |

**Abstract**

Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

**Objective**

The teaching goals of this course are on five different levels:
1. Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling, ...
2. Ability to use the fundamental concepts in applications
3. Insight into the role of boundary conditions (mainly part 2)
4. Knowledge of a number of applications.
5. Flavor of numerical techniques: finite elements and finite differences.

**Content**

Part 1 Approach to Transport Phenomena
- Equilibrium Thermodynamics
- Balance Equations
- Forces and Fluxes
- Applications
  1. Measuring Transport Coefficients
  2. Fluid mechanics
  3. combined heat and flow

**Lecture notes**


**Literature**


**Prerequisites / notice**

Physics:
- General undergraduate physics
- including basic chemical kinetics and thermodynamics

Chemistry:
- General undergraduate chemistry
- including basic chemical kinetics and thermodynamics

**Taught competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving

- Personal Competencies
  - Creative Thinking
  - Critical Thinking

| 327-1202-00L | Solid State Physics and Chemistry of Materials I | W Dr | 5 credits | 4G | N. Spaldin |

In this course we study how the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions.
**Course 327-1203-00L: Complex Materials I: Synthesis & Assembly**

**Objective:**
- Electronic properties and band theory description of conventional solids
- Electron-lattice coupling and its consequences in functional materials
- Electron-spin/orbit coupling and its consequences in functional materials
- Structure/property relationships in strongly-correlated materials

**Content:**
In this course we study how the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions. We begin with a review of the successes of band theory in describing many properties of metals, semiconductors and insulators, and we practise building up band structures from atoms and describing the resulting properties. Then we explore classes of systems in which the coupling between the electrons and the lattice is so strong that it drives structural distortions such as Peierls instabilities, Jahn-Teller distortions, and ferroelectric transitions. Next, we move on to strong couplings between electronic charge and spin-and/or orbital- angular momentum, yielding materials with novel magnetic properties. We end with examples of the complete breakdown of single-particle band theory in so-called strongly correlated materials, which comprise for example heavy-fermion materials, frustrated magnets, materials with unusual metal-insulator transitions and the high-temperature superconductors.

**Prerequisites / notice:**
- Statistical Thermodynamics (327-0315-00)
- Quantenmechanik für Materialwissenschaftler/innen (327-0316-00)
- Festkörpertheorie für Materialwissenschaftler/innen (327-0416-00)
- Electronic, Optical and Magnetic Properties of Materials (327-0512-00)

**Literature:**
An electronic script for the course is provided in Moodle.

**327-1204-00L: Materials at Work I**

**Objective:**
- Teaching goals:
  - to learn how materials are selected for a specific application
  - to understand how materials around us are produced and manufactured
  - to understand the value chain from raw material to application
  - to be exposed to state of the art technologies for processing, joining and shaping
  - to be exposed to industry related materials issues and the corresponding language (terminology) and skills
  - to create an impression of how a job in industry "works", to improve the perception of the demands of a job in industry

**Content:**
This course attempts to prepare the student for a job as a materials engineer in industry. The gap between fundamental materials science and the materials engineering of products should be bridged. The focus lies on the practical application of fundamental knowledge allowing the students to experience application related materials concepts with a strong emphasis on case-study mediated learning.

**Prerequisites / notice:**
- 1) Materialsynthese II (327-0412-00)
- 2) Kristalllographie (327-0104-00L), in particular structure of crystalline solids
- 3) Materials Characterization II (327-0413-00)

**Literature:**
References to original articles and reviews for further reading will be provided on the lecture notes.

**327-1207-00L: Engineering with Soft Materials**

**Objective:**
- Shaping
- Joining (assembly)
- Processing

**Content:**
- Lectures and case studies encompass the following topics:
  - Strategic Materials (where do raw materials come from, who owns them, who owns the IP and can they be substituted)
  - Materials Selection (what is the optimal material (class) for a specific application)
  - Materials systems (subdivisions include all classical materials classes)
  - Processing
  - Joining (assembly)
  - Shaping
  - Materials and process scaling (from nm to m and vice versa, from mg to tons)
  - Sustainable materials manufacturing (cradle to cradle)
  - Recycling (Energy recovery)

After a general part of materials selection, critical materials and materials and design four parts consisting of polymers, metals, ceramics and coatings will be addressed.

**Prerequisites / notice:**
- Manufacturing, Engineering & Technology
- Serope Kalpakjian, Steven Schmid
  - ISBN: 978-0131489653

**327-1208-00L: Introduction to Materials Synthesis Concepts**

**Objective:**
- Teaching goals:
  - to learn how to design and create objects as building blocks with a particular composition, size and shape, b) to understand the chemistry that allows for the creation of such hard and soft objects, and c) to master the concepts to assemble these objects into materials over several length scales.

**Content:**
The course is divided into two parts: I) synthesis of 0-, 1-, 2-, and 3-dimensional building blocks with a length scale from nm to µm, and II) assemblies of these building blocks into 1-, 2- and 3-dimensional structures over several length scales up to cm.

In part I, various methodologies for the synthesis of these blocks will be discussed, including Turkevich and Brust-Schiffrin-method for gold nanoparticles, hot-injection for semiconducting quantum dots, aqueous and nonaqueous sol-gel chemistry for metal oxides, or gas-and liquid-phase routes to carbon nanostructures. Part II is focused on self- and directed assembly methods that can be used to create higher order architectures from those building blocks connecting the microscopic with the macroscopic world. Examples include photonic crystals, nanocrystal solids, colloidal molecules, mesocrystals or particle-based foams and aerogels.

**Prerequisites / notice:**
- Manufacturing, Engineering & Technology
- Serope Kalpakjian, Steven Schmid
  - ISBN: 978-0131489653

**Literature:**
- Lecture notes
- Case studies

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1631 of 2345
### Elective Courses

The students are free to choose individually from the entire course offer of ETH Zürich on the Master level. Please consult the study administration in case of questions.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0702-00L</td>
<td>EM-Practical Course in Materials Science</td>
<td>W</td>
<td>2</td>
<td>4P</td>
<td>K. Kunze, S. Gerstl, F. Gramm, F. Krumeich, J. Reuteler</td>
</tr>
<tr>
<td>327-0703-00L</td>
<td>Electron Microscopy in Material Science</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze</td>
</tr>
</tbody>
</table>

**Abstract**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Objective**

This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

**Prerequisites / notice**

Attendance of lecture Electron Microscopy (327-0703-00L) is recommended. Maximum number of participants 15, work in groups of 3 people.

**Lecture notes**

will be distributed in English

**Literature**


Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-1101-00L</td>
<td>Biomineralization</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>K.-H. Ernst</td>
</tr>
</tbody>
</table>

**Abstract**

The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

**Objective**

The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

**Content**

Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, infra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / sintering in diatoms, radiolarians and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and invertebrate teeth
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

**Lecture notes**

Script with more than 600 pages with many illustrations will be distributed free of charge.

**Literature**

3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

**Prerequisites / notice**

No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-1221-00L</td>
<td>Biological and Bio-Inspired Materials</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. R. Studart, I. Burgert, R. Nicolosi Libanoni, G. Panzarasa</td>
</tr>
</tbody>
</table>

**Abstract**

The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials.

**Objective**

The course first offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials. Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.
This course is structured in 3 blocks:

**Block (I): Fundamentals of engineering in biological materials**
- Biological engineering principles
- Basic building blocks found in biological materials

**Block (II): Replicating biological design principles in synthetic materials**
- Biological and bio-inspired materials: polymer-reinforced and ceramic-toughened composites
- Lightweight biological and bio-inspired materials
- Functional biological and bio-inspired materials: surfaces, self-healing and adaptive materials

**Block (III): Bio-inspired design and systems**
- Mechanical actuation - plant systems
- Bio-inspiration in the built environment

**Lecture notes**
Copies of the slides will be made available for download before each lecture.

**Literature**
The course is mainly based on the books listed below. Additional references will be provided during the lectures.


**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

**Abstract**
Composites/hybrids are heterogeneous materials consisting of two or more bonded components, and it is possible to tailor material properties for certain applications. Typically, the components retain their structure and properties, but the properties of the composite are a combination of the properties of its components.

**Objective**
In this course you will get an inside to lightweight material with high strength, materials that are resistant against abrasion, ceramics with damage tolerance behavior, composites with bioactive, bioreabsorbable, piezoresistive and -electric properties. Enables materials scientists to design composite/hybrid materials for different applications. The course will comprise a balance of lectures, exercises and laboratory classes.

**Content**
Introduction and basic concepts on biomedical composites and smart composites/hybrids with sensing and actuation properties; production and properties of composites reinforced with particles, whiskers, short or long fibers; selection criteria, case studies and applications, future perspectives.

1. Structural composites (polymer-, metal- and ceramic matrix composites)
   1.1. Introduction and historical background
   1.2. Components: Matrix and reinforcement materials
   1.3. Types of composites and mechanisms of reinforcement
   1.4. Production processes
   1.5. Physical and chemical properties
   1.6. Applications

2. Biomedical Composites
   2.1. Introduction and historical background
   2.2. Components: metals/ alloys, natural/synthetic polymers, bioceramics
   2.3. Types of biocomposites
   2.4. Production processes
   2.5. Properties
   2.6. Applications

3. Functional Composites (Sensors and Actuators)
   3.1. Introduction and historical background
   3.2. Components: Matrix and functional filler material
   3.3. Types of composites
   3.4. Production processes
   3.5. Properties
   3.6. Applications

**Lecture notes**
We will work with handouts
Taught
competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Problem-solving</td>
<td>Project Management</td>
</tr>
</tbody>
</table>

Social Competencies

<table>
<thead>
<tr>
<th>Communication</th>
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<tbody>
<tr>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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</tbody>
</table>

Personal Competencies

<table>
<thead>
<tr>
<th>Negotiation</th>
<th>Adaptability and Flexibility</th>
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</thead>
<tbody>
<tr>
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<tr>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
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</table>

327-2125-00L Microscopy Training SEM I - Introduction to SEM

Abstract

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective

- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content

During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes

Lecture notes will be distributed.

Literature


Prerequisites / notice

No mandatory prerequisites.
High Resolution Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

**Abstract**

The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

**Objective**

Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

**Content**

Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

**Literature**


**Prerequisites / notice**

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.
The main goal of this hands-on course is to provide students with fundamental understanding of underlying physical processes, experimental set-up solutions and hands-on practical experience of analytical electron microscopy (AEM) technique for microstructure characterisation, specifically Energy Dispersive X-ray Spectroscopy (EDS) and spectrum imaging (SI) technique.

- understanding of physical processes that enable the EDS technique and data evaluation algorithms;
- hand-on experience of data acquisition and evaluation routines including
- practical understanding of different data acquisition set-ups,
- optimization of acquisition parameters for most reliable quantification of the results,
- the knowledge of the available and most reliable quantification algorithms and their handling
- the knowledge of data evaluation routines and possible handicaps for reliable elemental content distribution analyses and material composition quantification
- the effect of the specimen geometry on the data and experimental solutions for minimization of the artefacts

This advanced course provides analytical EM techniques to the students with prior EM experience (TEM or SEM). At the end of the course, students will understand the physical processes that enable the EDS technique and data evaluation algorithms and apply the technique for their own research.

- Introduction to analytical electron microscopy: theory and instrumentation.
- Lectures on EDS, WDS
- Practical on EDS-SEM: data acquisition and analysis.
- Practical on EDS-TEM: data acquisition and analysis.

The hand-on trainings are to be carried-out on a real-life specimen, provided by lecturers and/or students.

Provided in the course Moodle-page

- Carter & Williams: Transmission Electron Microscopy: Diffraction, Imaging and Spectrometry. Springer Verlag, 2016, DOI: 10.1007/978-3-319-26851-0

Master student or PhD student who has experience with EM (SEM or TEM) techniques or prior attendance of one of the following courses: Microscopy Training SEM1 (327-2125-00L) or Microscopy Training TEM1(327-2126-00L)
- Attendance of the following courses is of advantage, but not required: Scattering Techniques for Material Characterization (327-2137-00L) or Elements of Microscopy (227-0390-00L) or Electron Microscopy in Material Science (327-0703-00L)

327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation

W 2 credits 2G M. Trassin

The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed.

Oxide electronics device concepts will be discussed.

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basiscs-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

327-2135-00L Advanced Analytical TEM

Does not take place this semester.

W Dr 2 credits 3G to be announced

The course focuses on the fundamental understanding and hands-on knowledge of analytical Transmission Electron Microscopy (ATEM) techniques: electron dispersive X-ray analysis (EDX), energy filtered TEM and electron energy loss spectroscopy (EELS). The lectures will be followed by demonstrations and acquisition sessions TEM instruments. The lectures on statistical treatment of raw data sets and on practical understanding of different data acquisition set-ups,

- Setting-up the optimal operation conditions for reliable EDX analysis and quantification.
- Setting-up the optimal operation conditions for the reliable EFTEM analyses.
- Setting-up the optimal operation conditions for the reliable EELS analyses.
- EDX data acquisition, on-line analysis and quantification.
- EFTEM data acquisition and analysis.
- EELS acquisition analyses.

1. Fundamentals of analytical TEM.
4. EELS.
5. EFTEM.
7. EDX. Quantification and data evaluation.
8. Demonstrations on EDX, EELS, and EFTEM data acquisitions.
9. Practical sessions for students with provided specimens. Practical sessions for students with their own specimens.
10. Questions and such: open discussion.
11. Student presentations.


No mandatory prerequisites. Prior attendance to EM Basic lectures (327-0703-00L, 227-0390-00L) and to the Microscopy Training TEM I - Introduction to TEM course (327-2126-00L) is recommended.

327-2136-00L Chemical Analysis and Spectroscopy for Energy Applications

W Dr 2 credits 2G A. Borgschulte

This course provides an introduction to the chemical analysis and operando spectroscopy related to current scientific questions in energy research.
Objective

Objectives are the general physical concepts of physical and chemical analysis and their application on the most important questions in energy applications. Questions tackled include:
- What is determines selectivity / sensitivity of a technique?
- What is its spatial/temporal resolution?
- How to probe chemical reactions in action?

Content

Future as well as existing energy supply relies on the precise determination of the amount of the energy carrier either produced or spent. The devices used for this purpose range from simple ampere meter and its scientific pendant impedance spectrometer for electricity, and the chemical analysis of fuels and their combustion products. With the advent of renewable energy and its chemical or electro-chemical storage, there is increasing demand for advanced analysis tools as well as operando spectroscopy. The objective of the course is to introduce the physical basis of most commonly used methods, i.e., separation techniques (GC, MS), spectroscopic methods (impendence spectroscopy, UV-Vis-, IR-, Raman- spectroscopy), and scattering techniques (X-ray/photoelectron spectroscopy, neutron scattering) with focus on operando techniques. The methods are discussed within the framework of current scientific questions in renewable energy research such as the analysis of reaction mechanisms in thermo- and electro-catalysis and the in-situ characterization of new energy materials with particular focus on surface phenomena and gas-solid interactions.

The course will build on the Bachelor's degree courses Analytical Chemistry and Materials Characterization Methods.

327-2137-00L

Scattering Techniques for Material Characterization

All enrolled students are initially placed on the “waiting list” until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.

Abstract

The lecture presents the currently most efficient experimental techniques for microstructure material characterization: X-ray diffraction (XRD) and transmission electron microscopy (TEM). The theoretical basics, instrumentation, complementarity and exclusivity of both techniques will be taught. The course includes practical elements and examples of current research projects at D-MATL.

Objective

Students are able to do:
- systematically characterise the microstructure and phases of a given material with X-rays and electrons
- select the right tool (source, instrument, measurement strategy) and design a workflow for solving a microstructure or phase analysis problem
- describe possibilities and limitations of a given characterisation method
- comprehensively store experimentally collected data in a repository following modern data management rules such that data can be evaluated by students not involved in the experiment
- qualitatively and quantitatively evaluate and present experimental data and results collected by others

Content

The main objective of this hands-on practical course is to give students a comprehensive insight into the most important aspects of microstructure characterization using electron and X-ray scattering. The focus is on the complementarity and exclusivity of the two techniques. We will introduce the most important material characterization tasks, present the relevant physical and crystallographic fundamentals, and discuss how the tasks can be solved with electron and X-ray scattering. We will discuss intrinsic and extrinsic advantages and limitations of the methods and explain essential instrumentation requirements specific to each setup. Another essential facet of the course is the link to everyday D-MATL project problems presented by the lecturers or researchers from D-MATL. The lecture is accompanied by hands-on experiments on samples of D-MATL projects using state-of-the-art instruments.

Literature


Prerequisites / notice

Crystallography, X-ray diffraction and electron microscopy on the BSc level. All enrolled students are initially placed on the “waiting list” until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.

Taught competencies

Title:
- Subject-specific Competencies
- Method-specific Competencies
- Personal Competencies

Contents:
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Assessment:
- assessed
- assessed
- assessed
- assessed
- assessed
- assessed

W Dr 4 credits 2V+1U T. Weber, A. Sologubenko

327-2140-00L

Focused Ion Beam and Applications

Number of participants limited to 6. PhD students will be asked for a fee.

https://scopem.ethz.ch/education/MTP0.html

Registration form: (link will follow)

Abstract

The course on Focused Ion Beam (FIB) provides theoretical and hands-on learning, applying what is learned in lectures to hands-on sessions.

Objective

Overview of FIB theory, instrumentation. FIB hardware operation and applications. Set-up, align and operate a FIB-SEM successfully and safely. Accomplish operational tasks (milling and deposition) and optimize microscope parameters. Perform cross-sections: preparation and analysis Understanding of workflow for sample preparation (TEM lamella, APT needles, XCT pillars...) using FIB-SEM. Applying FIB-SEM for materials characterization.

W Dr 1 credit 2P P. Zeng, A. G. Bittermann, S. Gerstl, L. Grafuhlha Morales, J. Reuteler
Fatigue and Fracture in Materials and Structures

The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

In this course, the students will learn:

- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

Prior TEM experience.

327-2144-00L

Microscopy Training Cryogenic Electron Microscopy

Abstract

The introductory course on cryogenic electron microscopy (cryoEM) provides theoretical and hands-on learning for new operators, utilizing lectures, demonstrations and hands-on sessions.

Objective

- Overview of cryoEM theory, instrumentation, operation and applications
- Prepare cryoEM sample (vitrification using Vitrobot)
- Set-up, align and operate a cryoTEM successfully and safely
- Set up automated data collection
- Basic processing steps to analyze/interpret the data e.g., reconstruction 3D volumes

Content

This course introduces and gives an overview of cryoEM and its applications. At the end of the course, students will be familiar with how to prepare vitrified probe and how to use a cryoTEM to collect and analyze data for exemplary techniques:

- Introduction and discussion on cryoEM and instrumentation
- Lectures on cryoEM theory
- Lectures on cryoEM applications
- Practicals/demonstration on vitrification, grid preparation
- Practicals/demonstration on data collection
- Lecture and practicals/demonstration on reconstruction of 3D volumes from 2D cryoEM projections/images

Literature

- Course slides
- EM-University: (https://em-learning.com/)
- Book: CryoEM Methods and Protocols edited by T Gonen, B B Nannenga

Prerequisites / notice

- Prior attendance to the ScopeM Microscopy Training TEM I
- Prior TEM experience

101-0121-00L

Fatigue and Fracture in Materials and Structures

Does not take place this semester.

Objective

In this course, the students will learn:

- The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

Abstract

The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

Prior TEM experience.
Content

The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Linear elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and “Laboratory Competition”. The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- “Laboratory Competition” at Empa: the students with the closest predictions will win the “Empa Laboratory Competition” and will be awarded by a prize.

Lecture notes
Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Literature

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

101-0617-01L Advances in Building Materials W 4 credits 2G R. J. Flatt, I. Burgert

Abstract
The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

Objective
In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

Content
This course for civil engineers lays the grounds in the specialization Materials and Mechanics and complements the second introductory course of the specialization on Numerical Mechanics of Materials. The course also addresses master students in Materials Science and other study programs interested in deepening their understanding of application-relevant properties of engineering materials and sustainability related challenges.

The following topics are covered:
1. Material selection
2. Materials and sustainability 1
3. Materials and sustainability 2
4. Recyclability
5. Material science of wood durability
6. Material science of concrete durability
7. Foams in construction and thermal insulation
8. Sealants and adhesives in construction
9. Coatings
10. Flame retardants
11. Future of wood – 1
12. Future of wood – 2
13. Future of concrete – 1
14. Future of concrete – 2

Lecture notes
Handouts will be provided for each lecture.

101-0677-00L Concrete Technology W 2 credits 2G F. Constandopoulos, M. Bäuml, G. Martinola, T. Wangler

Abstract
Opportunities and limitations of concrete technology, Commodities and leading edge specialties, etc.

Objective
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.
Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as
  - self compacting concrete
  - fiber reinforced concrete
  - fast setting concrete
  - fair faced concrete
  - recycled concrete
- new research in digital fabrication with concrete

Lecture notes

Slides provided for download.

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

151-0353-00L Mechanics of Composite Materials W 4 credits 2V+1U P. Ermanni, G. Pappas

Abstract
Focus is on laminated fibre reinforced polymer composites. The courses treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

Objective
To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures made from fibre reinforced polymer composites, including elastic behaviour, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Content
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Variable stiffness structures

Lecture notes
Script, handouts, exercises and additional material are available in PDF-format on the CMASLab webpage resp on moodle.

https://moodle-app2.let.ethz.ch/course/view.php?id=2610

Literature
The lecture material is covered by the script and further literature is referenced in there.

151-0544-00L Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis W 4 credits 3G E. Hosseini

Abstract
An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective
The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUUS) for simulation of the MAM process.
Adaptive Materials for Structural Applications

W 4 credits 3G A. Bergamini

Abstract

Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated, also with laboratory experiments where possible.

Objective

The study of adaptive materials covers topics that range from chemistry to theoretical mechanics. The aim of this course is to convey knowledge about adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

Content

This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion


Thermo-mechanical coupling: Shape memory alloys / polymers

Electromechanical coupling(1): DEA, EBL, electrorheological fluids

Shape control / morphing: Use, requirements, challenges

Morphing applications of variable stiffness structures: Lab work

Electromechanical coupling (2): Piezoelectric, electrostrictive effect

Vibration Reduction: Measurement, passive, semi-active (active) damping methods

Vibration reduction applications of piezoelectric materials: Lab work

Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials

Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...

Lecture notes

Lecture notes (manuscript and handouts) will be provided

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Personal Competencies

Creative Thinking

Not assessed

Not assessed

Not assessed

Not assessed

Not assessed

Not assessed

Not assessed
## Content

The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale
Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

### Literature


### Prerequisites / notice

Course format:

Lectures and Mini-Review presentations: Thursday 10-13

Homework: Mini-Review (compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

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### Abstract

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

### Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

### Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

### Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

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**376-1714-00L**

**Biocompatible Materials**

| W | 4 credits | 3V | K. Maniura, M. Rottmar, M. Zenobi-Wong |

**Abstract**

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**

Handouts are deposited online (moodle).

**Literature**


(available online via ETH library)

Handouts and references therein.

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**402-0317-00L**

**Semiconductor Materials: Fundamentals and Fabrication**

| W | 6 credits | 2V+1U | S. Schön, W. Wegscheider |

**Abstract**

This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

**Objective**

Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

**Content**

1. Fundamentals of Solid State Physics
2. Semiconductor materials
3. Band structures
4. Carrier statistics in intrinsic and doped semiconductors
5. p-n junctions
6. Low-dimensional structures
7. Bulk Material growth of Semiconductors
8. Czochalski method
9. Floating zone method
10. High pressure synthesis
11. Semiconductor Epitaxy
12. Fundamentals of Epitaxy
13. Molecular Beam Epitaxy (MBE)
14. Metal-Organic Chemical Vapor Deposition (MOCVD)
15. Liquid Phase Epitaxy (LPE)
16. In situ characterization
17. Pressure and temperature
18. Reflectometry
19. Ellipsometry and RAS
20. LEED, AES, XPS
21. STM, AFM
22. The invention of the transistor - Christmas lecture
23. The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

**Lecture notes**

https://moodle-app2.let.ethz.ch/course/view.php?id=

**Prerequisites / notice**

The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.

1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help
The lecture "Introduction to Magnetism" is a regular course of the Physics MSc program and aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what "being magnetic" means is essential to address this question properly. Theoretical concepts will be applied to few selected nano-sized magnets, which will serve as clean reference systems.

At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Preliminary contents for the HS21:
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field).
- Spin resonance and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)
- Magnetic order at finite temperatures (Ising and Heisenberg models, low-dimensional magnetism)
- Dipolar interaction in solids (shape anisotropy, dipolar frustration, origin of magnetic domains)

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

4. Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations will be given. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitioned students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

<table>
<thead>
<tr>
<th>402-0809-00L</th>
<th>Introduction to Computational Physics</th>
<th>W</th>
<th>8 credits</th>
<th>2V+2U</th>
<th>A. Adelmann</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.</td>
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<tr>
<td>Objective</td>
<td>Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.</td>
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<tr>
<td>Content</td>
<td>Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes and slides are available online and will be distributed if desired.</td>
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<tr>
<td>Literature</td>
<td>Literature recommendations and references are included in the lecture notes.</td>
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<tr>
<td>Prerequisites/notice</td>
<td>Lecture and exercise lessons in english, exams in German or in English</td>
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529-0659-00L | Electrochemistry: Fundamentals, Cells & Applications | W | 6 credits | 3G | L. Gubler |
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<td>Abstract</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Content</td>
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<tr>
<td>Lecture notes</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Prerequisites/notice</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1645 of 2345
Abstract
Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.

Objective
The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of materials science and engineering and how they are put to use in selected applications.

Content
- Introduction: important quantities & units, terminology;
- Chapter I - Redox reactions, Faraday's laws;
- Chapter II - Equilibrium electrochemistry:
cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces:
electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes:
conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry:
overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry:
electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion:
important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors:
potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion:
corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

Lecture notes
lecture notes, exercise & solutions (PDF files) via download website

Literature
[German version available as well]

Prerequisites / notice
Students should be familiar with the fundamentals of physical chemistry.

Taught competencies
Subject-specific Competencies
Concepts and Theories
Assessed
Techniques and Technologies
Assessed

752-2314-00L

Abstract
Physics of Food Colloids
In Physics of Food Colloids the principles of colloid science will applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

Objective
The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Content
Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

Lecture notes
Notes will be handed out during the lectures.

Literature
Provided in the lecture notes.

551-0357-00L

Abstract
Cellular Matters: From Milestones to Open Questions
The number of participants is limited to 22 and will only take place with a minimum of 11 participants.
Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using in the subject: 551-0357-00.
In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

In this course, the students will explore the quite new topic of biomolecular condensates.
Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.
In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion. With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverons on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

The presentations will be made available after the lectures. The milestone papers will be provided in advance. For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

### Projects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>327-1210-00L</td>
<td>Project I</td>
<td>Independent scientific practice of 8 weeks which is completed with a written report.</td>
<td>12 credits</td>
<td>23A</td>
<td>Professors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.</td>
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<td>Objective</td>
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<tr>
<td>327-1211-00L</td>
<td>Project II</td>
<td>Independent scientific practice of 8 weeks which is completed with a written report.</td>
<td>12 credits</td>
<td>23A</td>
<td>Professors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.</td>
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<td>Objective</td>
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### Master’s Thesis

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>327-9000-00L</td>
<td>Master’s Thesis</td>
<td>Only students who fulfill the following criteria are allowed to begin with their master thesis: a. successful completion of the bachelor programme; b. fulfilling of any additional requirements necessary to gain admission to the master programme.</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Independent scientific work of current topics in the field of materials science. Duration 6 months. The work is documented in a written form.</td>
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<tr>
<td>Objective</td>
<td>Master thesis is a six month fulltime project and will encourage the students to work independently and in a structured and scientific way. It is guided by a professor of the Department of Materials.</td>
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</table>

### Science in Perspective

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-MATL

- see Science in Perspective: Language Courses ETH/UZH

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

#### Materials Science Master - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Courses outside the curriculum</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Suitable for doctorate</th>
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<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<table>
<thead>
<tr>
<th>Type</th>
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<tbody>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
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#### Key for Hours

<table>
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<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<table>
<thead>
<tr>
<th>Type</th>
<th>independent project</th>
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<tr>
<th>Type</th>
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</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>revision course / private study</th>
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<tbody>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>
### Mathematics (General Courses)

#### Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>R. Abgrall, M. Iacobelli, A. Bandeira, A. Iozzi, S. Mishra, R. Pandharipande, University lecturers</td>
</tr>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>N. Hungerbühler, M. Akveld, D. Grawehr Morath, J. Hromkovic, P. Spindler</td>
</tr>
</tbody>
</table>

Abstract
Didactics colloquium

#### Actuary SAA Education at ETH Zurich

Further pieces of information are available at Prof. M. Wüthrich’s secretariat, HG F 42.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3925-00L</td>
<td>Non-Life Insurance: Mathematics and Statistics</td>
<td>W</td>
<td>8</td>
<td>4V+1U</td>
<td>M. V. Wüthrich</td>
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</tbody>
</table>

Abstract
The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

Objective
The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

Content
The following topics are treated:
- Collective Risk Modeling
- Individual Claim Size Modeling
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tariffication
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

Lecture notes
M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
http://ssrn.com/abstract=2319328

Literature
M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications
http://ssrn.com/abstract=3822407

Prerequisites / notice
The exams ONLY take place during the official ETH examination period (and they will be in person at ETH, this also applies to exchange/mobility students).

This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

Taught competencies
- Subject-specific Competencies
  - Techniques and Technologies: assessed
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed

401-3922-00L | Life Insurance Mathematics                        | W    | 4     | 2V    | M. Koller                  |

Abstract
The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

401-3929-00L | Financial Risk Management in Social and Pension | W    | 4     | 2V    | P. Blum                    |

Abstract
Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. We study short-term and long-term financial risk and its interplay with other risk factors, and we develop methods for the measurement and management of financial risk and return in an asset/liability context with the goal of assuring sustainable funding.
Understand the basic asset-liability framework: essential principles and properties of social and pension insurance; cash flow matching, duration matching, valuation portfolio and loose coupling; the notion of financial risk; long-term vs. short-term risk; coherent measures of risk.

Understand the conditions for sustainable funding: derivation of required returns; interplay between return levels, contribution levels and other parameters; influence of guaranteed benefits.

Understand the notion of risk-taking capability: capital process as a random walk; measures of long-term risk and relation to capital; short-term solvency vs. long-term stability; effect of embedded options and guarantees; interplay between required return and risk-taking capability.

Be able to study empirical properties of financial assets: the Normal hypothesis and the deviations from it; statistical tools for investigating relevant risk and return properties of financial assets; time aggregation properties; be able to conduct analysis of real data for the most important asset classes.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Have an overall view: see the big picture of what asset returns can and cannot contribute to social security; be aware of the most relevant outcomes; know the role of the actuary in the financial risk management process.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.

<table>
<thead>
<tr>
<th>Objective</th>
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<tbody>
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<td>Reinsurance Analytics</td>
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<tr>
<td>Does not take place this semester.</td>
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</table>

Abstract

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1649 of 2345
Content

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes. Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

Lecture notes

Slides and lecture notes will be made available.

Prerequisites / notice

Basic knowledge in statistics, probability theory, and actuarial techniques.

401-3927-00L Mathematical Modelling in Life Insurance

W 4 credits 2V

Content

Following main topics are covered:

1. Guarantees and options embedded in life insurance products.
   - Stochastic valuation of participating contracts
   - Stochastic valuation of Unit Link contracts
2. Mortality Tables:
   - Determining raw mortality rates
   - Smoothing techniques: Whittaker-Henderson, smoothing splines, ...
   - Trends in mortality rates
   - Stochastic mortality model due to Lee and Carter
   - Neural Network extension of the Lee-Carter model
   - Integration of safety margins
3. Determining unit link values
   - Stochastic valuation of Unit Linked contracts

Lecture notes

An excerpt of last year's lecture notes is available here: https://sites.google.com/site/philipparbenz/reinsuranceanalytics

401-3913-01L Mathematical Foundations for Finance

W 4 credits 3V+2U M. Schweizer

Content

Topics to be covered include:
- Financial market models in finite discrete time
- Absence of arbitrage and martingale measures
- Valuation and hedging in complete markets
- Basics about Brownian motion
- Stochastic integration
- Stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Good knowledge in probability theory and stochastic processes is assumed. Some knowledge in financial mathematics is useful.
Responsible Machine Learning with Insurance Applications

- Lecture notes will be sold at the beginning of the course. Additional (background) references are given there.
- Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

401-3931-00L Principles of Microeconomics

- Taught competencies
  - Subject-specific Competencies
    - Concepts and Theories: assessed
    - Techniques and Technologies: not assessed
  - Method-specific Competencies
    - Analytical Competencies: assessed
    - Decision-making: not assessed
    - Media and Digital Technologies: not assessed
    - Problem-solving: assessed
    - Project Management: not assessed
  - Social Competencies
    - Communication: not assessed
    - Cooperation and Teamwork: not assessed
    - Customer Orientation: not assessed
    - Leadership and Responsibility: not assessed
    - Self-presentation and Social Influence: assessed
    - Sensitivity to Diversity: not assessed
    - Negotiation: not assessed
  - Personal Competencies
    - Adaptability and Flexibility: not assessed
    - Creative Thinking: not assessed
    - Critical Thinking: assessed
    - Integrity and Work Ethics: not assessed
    - Self-awareness and Self-reflection: not assessed
    - Self-direction and Self-management: not assessed

401-3930-00L Risk and Insurance Economics

- Objective
  - The course covers the economics of risk and insurance, in particular the following topics will be discussed:
    1) individual decision making under risk
    3) models of insurance demand, risk sharing, insurance supply
    4) information issues in insurance markets
    5) advanced topics in microeconomics and behavioral economics
    5) the macroeconomic role of insurers and insurance regulation

- Prerequisites / notice
  - Prerequisites: Good knowledge in statistics/probability theory, statistical modelling and the R programming language are assumed.

This course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

This book can also be used for the course "363-0503-00L Principles of Microeconomics" (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

401-3930-00L Risk and Insurance Economics

- Abstract
  - This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

- Content
  - This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.
  - This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

- Notice
  - Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

- Literature
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Main literature:
- Handbook of the Economics of Risk and Uncertainty. Volume 1;

Further readings:

References will be given on a topic-by-topic basis during the course.

### Literature

- **Main literature:**
  - Handbook of the Economics of Risk and Uncertainty. Volume 1;

- **Further readings:**

## Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

## Mathematics (General Courses) - Key for Type

| Z | Courses outside the curriculum | W+ | Eligible for credits and recommended |
| Dr | Suitable for doctorate | W | Eligible for credits |
| O | Compulsory | E- | Recommended, not eligible for credits |

## Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium | |

## ECTS

| European Credit Transfer and Accumulation System | |
| Special students and auditors need special permission from the lecturers. | |
## First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10</td>
<td>6V+3U</td>
<td>G. Felder</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.</td>
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<tr>
<td>Objective</td>
<td>The ability to work with the basics of calculus in a mathematically rigorous way.</td>
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</tr>
</tbody>
</table>
| Literature   | J. Apell: Analysis in Beispielen und Gegenbeispielen  
|              | R. Courant: Vorlesungen über Differential- und Integralrechnung  
|              | O. Forster: Analysis I  
|              | H. Heuser: Lehrbuch der Analysis  
|              | K. Königsberger: Analysis I  
|              | https://link.springer.com/book/10.1007/978-3-642-18490-1  
|              | W. Walter: Analysis I  
|              | https://link.springer.com/book/10.1007/978-3-540-35078-0  
|              | V. Zörch: Mathematical Analysis I (englisch)  
|              | A. Beutelspacher: "Das ist o.B.d.A. trivial"  
|              | H. Schichl, R. Steinbauer: Einführung in das mathematische Arbeiten  
| 402-1701-00L | Physics I                                | O    | 7    | 4V+2U   | W. Wegscheider       |
| Abstract     | This course gives a first introduction to Physics with an emphasis on classical mechanics.  |
| Objective    | Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.  |

## First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>P. Biran, M. Einsiedler</td>
</tr>
</tbody>
</table>
| Objective    | Mastering basic concepts of Linear Algebra  
|              | Introduction to mathematical methods  
| Content      | Basics  
|              | Vectorspaces and linear maps  
|              | Systems of linear equations and matrices  
|              | Determinants  
|              | Endomorphisms and eigenvalues  
| Lecture notes| We will provide German lecture notes and an English translation at latest at the start of the semester.  |
Literature

Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester. Besides this we also recommend:

In addition we recommend this general introduction into studying mathematics:

### Compulsory Courses

#### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>E. Kowalski</td>
</tr>
</tbody>
</table>

**Abstract**

Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.

**Objective**

Working knowledge of functions of one complex variables; in particular applications of the residue theorem.

**Literature**


Th. Gamelin: Complex Analysis. Springer 2001


D. Salamon: "Funktionentheorie". Birkhauser, 2011. (In German)


K.Jaenich: Funktionentheorie. Springer Verlag

R.Remmert: Funktionentheorie I. Springer Verlag

E.Hille: Analytic Function Theory. AMS Chelsea Publications

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2653-21L</td>
<td>Numerical Analysis I</td>
<td>O</td>
<td>7</td>
<td>3V+2U</td>
<td>C. Schwab</td>
</tr>
</tbody>
</table>

**Abstract**

This course will give an introduction to mathematical analysis of numerical methods, aimed at mathematics majors. It covers numerical linear algebra, quadrature, interpolation and approximation methods as well as their error analysis and implementation.

**Objective**

Knowledge of the fundamental numerical methods, their mathematical foundation as well as numerical literacy: application of numerical methods for the solution of application problems, mathematical foundations of numerical methods, and basic mathematical methods of the analysis of stability, consistency and convergence of numerical methods, MATLAB implementation.

**Content**

Rounding errors, direct solution of linear systems of equations, iterative solution of systems of nonlinear equations, interpolation and approximation (polynomial as well as trigonometric), least squares problems, extrapolation, numerical quadrature, elementary optimization methods, fast Fourier transformation.

**Lecture notes**

Lecture Notes and reading list will be available.

**Literature**

Lecture Notes (german or english) will be made available to registered students of ETH BSc MATH.

Quarteroni, Sacco and Saleri, Numerische Mathematik 1 + 2, Springer Verlag 2002 (in German).

There is an English version of this text, containing both German volumes, from the same publisher. If you feel more comfortable with English, you can follow this text as well. Content and Indexing are identical in the German and the English text.

**Prerequisites / notice**

Admission Requirements:
Completed courses and passed written exams
Linear Algebra I, Analysis I in ETH BSc MATH
Linear Algebra II, Analysis II in ETH BSc MATH

Weekly homework assignments involving MATLAB programming are an integral part of the course.
Turn-in of solutions will be graded.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

401-2003-00L Algebra I O 7 credits 3V+2U R. Pink
Abstract
Introduction and development of some basic algebraic structures - groups, rings, fields.

Objective
Introduction to basic notions and results of group, ring and field theory.

Content
Group Theory: basic notions and examples of groups, subgroups, factor groups, homomorphisms, group actions, Sylow theorems, applications

Ring Theory: basic notions and examples of rings, ring homomorphisms, ideals, factor rings, euclidean rings, principal ideal domains, factorial rings, applications

Field Theory: basic notions and examples of fields, field extensions, algebraic extensions, applications

Literature
- Karpfinger-Meyberg: Algebra, Spektrum Verlag
- S. Bosch: Algebra, Springer Verlag
- B.L. van der Waerden: Algebra I und II, Springer Verlag
- S. Lang, Algebra, Springer Verlag
- A. Knapp: Basic Algebra, Springer Verlag
- J. Rotman, "Advanced modern algebra, 3rd edition, part 1"
- J.F. Humphreys: A Course in Group Theory (Oxford University Press)
- G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)
- S. Lang, Algebra, Springer Verlag
- A. Knapp: Basic Algebra, Springer Verlag
- J. Rotman, "Advanced modern algebra, 3rd edition, part 1"
- J.F. Humphreys: A Course in Group Theory (Oxford University Press)
- G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)
- M. Artin: Algebra (Birkhaeuser Verlag)

401-2283-00L Analysis III (Measure Theory) O 6 credits 3V+2U F. Da Lio
Abstract
Measure and integration theory, including: Caratheodory's theorem, Lebesgue measure, Radon measure, Hausdorff measure, convergence theorems, L^p spaces, Radon-Nikodym theorem, product measure and Fubini's theorem

Objective
Basics of abstract measure and integration theory

Content
Measure Spaces (Lebesgue Measure, Hausdorff Measure, Radon Measure)
- Measurable Functions: definition and properties
- Integration: definition, properties, theorems of convergence, Lebesgue L^p spaces
- Product Measures and Multiple Integrals. Fubini and Tonelli Theorems, Convolutions
- Differentiation of measures (if time permits)

Lecture notes

Literature
1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy "Measure theory and fine properties of functions"
3. Walter Rudin "Real and complex analysis"
4. R. Bartle The elements of Integration and Lebesgue Measure
   http://www.mat.uniroma2.it/~cannarsa/cam_0607.pdf

Prerequisites / notice
Analysis 1 & 2 und basic notions of topology

Minor Courses

402-2883-00L Physics III W 7 credits 4V+2U Y. Chu
Abstract
Introductory course on quantum and atomic physics including optics and statistical physics.

Objective
A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.
### Content

Einführung in die Quantenphysik: Planck’sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrsche Atommodell, de-Broglie Materiewellen.

Optik/Wellenoptik: Linsen, Abbildungssysteme, Brechung und Fermatsches Prinzip, Beugung, Interferenz, Fabry-Perot, Interferometer, Spektrometer.

Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentialkasten, harmonischer Oszillator


Lecture notes

Im Rahmen der Veranstaltung werden die Folien in elektronischer Form zur Verfügung gestellt. Ergänzende Bücher wird als Pflichtlektüre empfohlen. Es wird kein Skript in der Vorlesung verteilt.

Wir werden die Quantenmechanik anhand der Schrödinger-Gleichung mit den klassischen elektro-magnetischen Wellen vergleichen. Zu den klassischen Wellen werden Ergänzungsunterlagen verteilt.

Literature

M. Alonso, E. J. Finn
Quantenphysik und Statistische Physik
R. Oldenbourg Verlag, München
5. Auflage
ISBN 978-3-486-71340-4

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Semester</th>
<th>Credits</th>
<th>3/4V+2U</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-2203-01L</td>
<td>Classical Mechanics</td>
<td>W</td>
<td>7</td>
<td>4V+2U</td>
<td>M. Gaberdiel</td>
</tr>
<tr>
<td>252-0057-00L</td>
<td>Theoretical Computer Science</td>
<td>W</td>
<td>7</td>
<td>4V+2U</td>
<td>J. Hromkovic, H.-J. Böckenhauer, D. Komm</td>
</tr>
</tbody>
</table>

Abstract

Classical Mechanics
A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

Theoretical Computer Science
Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be used? d) What is nondeterminism and what role does it play in CS? e) How to represent infinite objects by finite automata and grammars?

Objective

Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

Objective

Learning the basic concepts of computer science along their historical development

Content

This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:

- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

Lecture notes

The lecture is covered in detail by the textbook "Theoretical Computer Science".

Literature

Basic literature:


Further reading:


More exercises and examples in:

6. A. Asteroth, Ch. Baier: Theoretische Informatik

Prerequisites / notice

During the semester, two non-obligatory test exams will be offered.

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Im Rahmen der Veranstaltung werden die Folien in elektronischer Form zur Verfügung gestellt. Ergänzende Buch wird als Pflichtlektüre empfohlen. Es wird kein Skript in der Vorlesung verteilt.

**Course Units**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>E. Kowalski</td>
</tr>
<tr>
<td>Abstract</td>
<td>Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.</td>
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<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Working knowledge of functions of one complex variables; in particular applications of the residue theorem.</td>
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</tr>
<tr>
<td></td>
<td>Th. Gamelin: Complex Analysis. Springer 2001</td>
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<tr>
<td></td>
<td>D. Salamon: &quot;Funktionentheorie&quot;. Birkhauser, 2011. (In German)</td>
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<tr>
<td></td>
<td>K.Jaenic: Funktitionentheorie. Springer Verlag</td>
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<tr>
<td></td>
<td>R.Remmert: Funktionentheorie I. Springer Verlag</td>
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</tr>
<tr>
<td>E.Hille: Analytic Function Theory. AMS Chelsea Publications</td>
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</tr>
<tr>
<td>401-2333-00L</td>
<td>Mathematical Methods of Physics I</td>
<td>O</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>T. H. Willwacher</td>
</tr>
<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>W</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>Y. Chu</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introductory course on quantum and atomic physics including optics and statistical physics.</td>
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</tr>
<tr>
<td>Objective</td>
<td>A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Einführung in die Quantenphysik: Planck’sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrscbe Atombmodell, de-Broglie Materiewellen.</td>
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<tr>
<td></td>
<td>Optik/Wellenoptik: Linsen, Abbildungssysteme, Brechung und Fermatsches Prinzip, Beugung, Interferenz, Fabry-Perot, Interferometer, Spektrometer.</td>
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<tr>
<td></td>
<td>Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentkasten, harmonischer Oszillator</td>
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</tr>
<tr>
<td>Literature</td>
<td>M. Alonso, E. J. Finn</td>
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<tr>
<td></td>
<td>Quantenphysik und Statistische Physik R. Oldenbourg Verlag, München 5. Auflage ISBN 978-3-486-71340-4</td>
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<tr>
<td>402-2203-01L</td>
<td>Classical Mechanics</td>
<td>W</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>M. Gaberdiel</td>
</tr>
<tr>
<td>Abstract</td>
<td>A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.</td>
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<tr>
<td>Objective</td>
<td>Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.</td>
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</table>

**Exam Block I**

In Examination Block I either the course unit 402-2283-00L Physics III or the course unit 402-2203-01L Classical Mechanics must be chosen and registered for an examination. (Students may also enrol for the other of the two course units; within the ETH Bachelor's programme in mathematics, this other course unit cannot be registered in myStudies for an examination nor can it be recognised for the Bachelor's degree.)

For 252-0851-00L Algorithms and Complexity, see http://www.vvz.ethz.ch/Vorlesungsverzeichnis/lerneinheit.view?lang=en&lerneinheitid=147860&semkez=2021W&ansicht=LEHRVERANSTALTUNGEN

**Exam Block II**

Students who have not yet tried the Examination Block 2 (Regulations 2016) can choose to take 401-2283-00L Analysis III (Measure Theory) instead of 401-2284-00L Measure and Integration. To register for 401-2283-00L Analysis III (Measure Theory), please contact exams@ethz.ch. In case of a repetition of the Examination Block 2, the same course as in the first try will be examined.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2003-00L</td>
<td>Algebra I</td>
<td>O</td>
<td>7 credits</td>
<td>3V+2U</td>
<td>R. Pink</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction and development of some basic algebraic structures - groups, rings, fields. Introduction to basic notions and results of group, ring and field theory.</td>
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</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1657 of 2345
Content

Group Theory: basic notions and examples of groups, subgroups, factor groups, homomorphisms, group actions, Sylow theorems, applications.

Ring Theory: basic notions and examples of rings, ring homomorphisms, ideals, factor rings, euclidean rings, principal ideal domains, factorial rings, applications.

Field Theory: basic notions and examples of fields, field extensions, algebraic extensions, applications.

Factor Theory: basic notions and examples of fields, field extensions, algebraic extensions, applications.

Literature

Karpfinger-Meyberg: Algebra, Spektrum Verlag
S. Bosch: Algebra, Springer Verlag
B.L. van der Waerden: Algebra I und II, Springer Verlag
S. Lang, Algebra, Springer Verlag
A. Knapp: Basic Algebra, Springer Verlag
J.F. Humphreys: A Course in Group Theory (Oxford University Press)
G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)
M. Artin: Algebra (Birkhaeuser Verlag)

401-2283-00L Analysis III (Measure Theory) W 6 credits 3V+2U F. Da Lio

Abstract

Measure and integration theory, including: Caratheodory's theorem, Lebesgue measure, Radon measure, Hausdorff measure, convergence theorems, L^p spaces, Radon-Nikodym theorem, product measure and Fubini's theorem.

Objective

Basics of abstract measure and integration theory.

Content

Measure Spaces (Lebesgue Measure, Hausdorff Measure, Radon Measure)
- Measurable Functions: definition and properties
- Integration: definition, properties, theorems of convergence, Lebesgue L^p spaces
- Product Measures and Multiple Integrals. Fubini and Tonelli Theorems, Convolutions
- Differentiation of measures (if time permits)

Lecture notes


Literature

1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy "Measure theory and fine properties of functions"
3. Walter Rudin "Real and complex analysis"
4. R. Bartle The elements of Integration and Lebesgue Measure

Prerequisites / notice

Analysis 1 & 2 und basic notions of topology.

Minor Courses

402-0351-00L Astronomy W 2 credits 2V H. M. Schmid, A. M. Glauser

Abstract

An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology.

Objective

This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.

Content

Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie.

Lecture notes

Kopien der Präsentationen werden zur Verfügung gestellt.

Literature

Der Neue Kosmos. A. Unsöld, B. Baschek, Springer

Oder sonstige Grundlehrbücher zur Astronomie.

Core Courses (Programme Regulations 2016)

252-0057-00L Theoretical Computer Science W 7 credits 4V+2U J. Hromkovic, H.-J. Böckenhauer, D.-Komm

Abstract

Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be useful? d) What is nondeterminism and what role does it play in CS? e) How to represent infinite objects by finite automata and grammars?

Objective

Learning the basic concepts of computer science along their historical development.

Content

This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:

- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

Lecture notes

The lecture is covered in detail by the textbook "Theoretical Computer Science".
**Literature**

Basic literature:


Further reading:


More exercises and examples in:

6. A. Asteroth, Ch. Baier: Theoretische Informatik

**Prerequisites / notice**

During the semester, two non-obligatory test exams will be offered.

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**Core Courses**

**Core Courses: Pure Mathematics**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3531-00L</td>
<td>Differential Geometry I</td>
<td>W</td>
<td>10</td>
<td>4V+1U</td>
<td>J. Serra</td>
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<td>At most one of the three course units (Bachelor Core Courses)</td>
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<td></td>
<td>401-3461-00L Functional Analysis I</td>
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<td>401-3531-00L Differential Geometry I</td>
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<td></td>
<td>401-3601-00L Probability Theory</td>
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<td></td>
<td>can be recognised for the Master's degree in Mathematics</td>
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<td></td>
<td>or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (<a href="http://www.math.ethz.ch/studiensekretariat">www.math.ethz.ch/studiensekretariat</a>) after having received the credits.</td>
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**Core Courses: Pure Mathematics (Mathematics Master)**

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3461-00L</td>
<td>Functional Analysis I</td>
<td>W</td>
<td>10</td>
<td>4V+1U</td>
<td>P. Hintz</td>
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<td>At most one of the three course units (Bachelor Core Courses)</td>
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<td>401-3461-00L Functional Analysis I</td>
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<td>401-3531-00L Differential Geometry I</td>
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<td>401-3601-00L Probability Theory</td>
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<td>can be recognised for the Master's degree in Mathematics</td>
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<td>or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (<a href="http://www.math.ethz.ch/studiensekretariat">www.math.ethz.ch/studiensekretariat</a>) after having received the credits.</td>
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**Core Courses: Pure Mathematics (Mathematics Master)**

**Core Courses: Pure Mathematics (Mathematics Master)**

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**Prerequisites / notice**

Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and $L^p$ spaces).
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Type</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>401-3001-61L</td>
<td>Algebraic Topology I</td>
<td>W</td>
<td>8</td>
<td>S. Kalisnik Hintz</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>This is an introductory course in algebraic topology, which is the study of algebraic invariants of topological spaces. Topics covered include: singular homology, cell complexes and cellular homology, the Eilenberg-Steenrod axioms.</td>
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<td></td>
<td><strong>Literature</strong></td>
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<td></td>
<td>See also: <a href="http://www.math.cornell.edu/~hatcher/#anchor1772800">http://www.math.cornell.edu/~hatcher/#anchor1772800</a></td>
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<td>3) E. Spanier, “Algebraic topology”. Springer-Verlag</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>You should know the basics of point-set topology. Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course &quot;topology&quot;). Some knowledge of differential geometry and differential topology is useful but not strictly necessary. Some (elementary) group theory and algebra will also be needed.</td>
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<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Type</th>
<th>Lecturer</th>
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<tbody>
<tr>
<td>401-3132-00L</td>
<td>Commutative Algebra</td>
<td>W</td>
<td>10</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course provides an introduction to commutative algebra. It serves in particular as a foundation for modern algebraic geometry.</td>
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<td><strong>Objective</strong></td>
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<td>The topics presented in the course will include:</td>
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<td></td>
<td>• Basics facts about rings, ideals and modules</td>
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<td></td>
<td>• Constructions of rings: quotients, polynomial rings, localization</td>
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<td>• Noetherian rings and modules</td>
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<td></td>
<td>• The tensor product of modules over commutative rings and its applications</td>
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<td></td>
<td>• Krull dimension</td>
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<td></td>
<td>• Integral extensions and the Cohen-Seidenberg theorems</td>
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<td></td>
<td>• Finitely generated algebras over fields, including the Noether Normalization Theorem and the Nullstellensatz</td>
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<td></td>
<td>• Primary decomposition</td>
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<td>• Discrete valuation rings and some applications</td>
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<td></td>
<td><strong>Literature</strong></td>
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<td></td>
<td><strong>Primary Reference:</strong></td>
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<td></td>
<td><strong>Secondary References:</strong></td>
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<td>4. &quot;Commutative Algebra&quot; by N. Bourbaki</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Prerequisites: Algebra I/II (or a similar introduction to the basic concepts of ring theory, including field theory).</td>
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<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Type</th>
<th>Lecturer</th>
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</thead>
<tbody>
<tr>
<td>401-3111-72L</td>
<td>Number Theory I</td>
<td>W</td>
<td>8</td>
<td>S. Zerbes</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course will give an introduction to the theory of number fields, which are fundamental objects in algebraic number theory. In this course, we will cover the following topics:</td>
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<td>- review of field extensions, algebraic numbers</td>
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<td></td>
<td>- rings of integers, discriminants, integral bases</td>
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<td></td>
<td>- examples: cyclotomic fields</td>
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<td></td>
<td>- non-unique factorisation of algebraic integers, unique factorisation into prime ideals</td>
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<td>- fractional ideals, class groups</td>
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<td></td>
<td>- lattices and Minkowski's lemma, finiteness of the class group</td>
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<td>- computations of the class number</td>
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<td>- group of units of a number field</td>
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<td>- Dedekind zeta functions, class number formula</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Type</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-8141-00L</td>
<td>Algebraic Geometry (University of Zurich)</td>
<td>W</td>
<td>9</td>
<td>University lecturers</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Projective varieties, projective geometry, schemes.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH. UZH Module Code: MAT507</td>
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<td></td>
<td>Mind the enrolment deadlines at UZH: <a href="https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html">https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html</a></td>
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<td></td>
<td>A related course is 401-3146-12L Algebraic Geometry. Although both courses can be taken independently of each other, only one will be recognised for credits in the Bachelor and Master degree. In particular, it is not allowed to earn credit points with one for the Bachelor and with the other for the Master degree.</td>
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</tbody>
</table>
Objective To acquire familiarity with basic properties of projective varieties; some scheme theory.

Core Courses: Applied Mathematics and Further Appl.-Oriented Fields

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3651-00L</td>
<td>Numerical Analysis for Elliptic and Parabolic Partial Differential Equations</td>
<td>W</td>
<td>9 credits</td>
<td>4V+1U</td>
<td>H. Ammari</td>
</tr>
</tbody>
</table>

Objective

To acquire familiarity with basic properties of projective varieties; some scheme theory.

Core Courses: Applied Mathematics and Further Appl.-Oriented Fields

Number | Title                                                      | Type | ECTS | Hours   | Lecturers |
--------|------------------------------------------------------------|------|------|---------|-----------|
401-3651-00L | Numerical Analysis for Elliptic and Parabolic Partial Differential Equations | W    | 9 credits | 4V+1U  | H. Ammari |

Abstract

This course gives a comprehensive introduction into the numerical treatment of linear and nonlinear elliptic boundary value problems, related eigenvalue problems and linear, parabolic evolution problems. Emphasis is on theory and the foundations of numerical methods.

Objective

Participants of the course should become familiar with

* concepts underlying the discretization of elliptic and parabolic boundary value problems
* analytical techniques for investigating the convergence of numerical methods for the approximate solution of boundary value problems
* methods for the efficient solution of discrete boundary value problems
* implementational aspects of the finite element method

Content

The course will address the mathematical analysis of numerical solution methods for linear and nonlinear elliptic and parabolic partial differential equations. Functional analytic and algebraic (De Rham complex) tools will be provided. Primal, mixed and nonstandard (discontinuous Galerkin, Virtual, Trefftz) discretizations will be analyzed.

A selection of the following topics will be covered:

* Elliptic boundary value problems
* Galerkin discretization of linear variational problems
* The primal finite element method
* Mixed finite element methods
* Discontinuous Galerkin Methods
* Boundary element methods
* Spectral methods
* Adaptive finite element schemes
* Singularly perturbed problems
* Sparse grids
* Galerkin discretization of elliptic eigenproblems
* Non-linear elliptic boundary value problems
* Discretization of parabolic initial boundary value problems

Literature


Additional Literature:

D. Braess: Finite Elements, THIRD Ed., Cambridge Univ. Press, (2007). (Also available in German.)


Prerequisites / notice

Practical exercises based on MATLAB

Former title of the course unit: Numerical Methods for Elliptic and Parabolic Partial Differential Equations

401-3601-00L Probability Theory

At most one of the three course units (Bachelor Core Courses)

401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains.

- Linear & Combinatorial Optimization


- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

- Linear & Combinatorial Optimization

- H. Bauer, Probability Theory, de Gruyter 1996
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- D. Williams, Probability with martingales, Cambridge University Press 1991

Abstract

Basics of probability theory and the theory of stochastic processes in discrete time

Objective

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains.

Content

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains.

Lecture notes

will be available in electronic form.

Literature

H. Bauer, Probability Theory, de Gruyter 1996
J. Jacod and P. Protter, Probability essentials, Springer 2004
A. Klenke, Wahrscheinlichkeitstheorie, Springer 2006
D. Williams, Probability with martingales, Cambridge University Press 1991

401-3621-00L Fundamentals of Mathematical Statistics

Abstract

The course covers the basics of inferential statistics.

Objective

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains.

Content

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains.

Lecture notes

will be available in electronic form.

Literature

H. Bauer, Probability Theory, de Gruyter 1996
J. Jacod and P. Protter, Probability essentials, Springer 2004
A. Klenke, Wahrscheinlichkeitstheorie, Springer 2006
D. Williams, Probability with martingales, Cambridge University Press 1991

401-3901-00L Linear & Combinatorial Optimization

Abstract

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Key topics include:

- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

401-3622-00L Statistical Modelling

Abstract

In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

Objective

Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

Content


Prerequisites / notice

This is the course unit with former course title "Regression".

Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

252-0209-00L Algorithms, Probability, and Computing

Abstract

Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

Objective

Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

Content


Prerequisites / notice

This is the course unit with former course title "Regression".

Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1662 of 2345
Advanced design and analysis methods for algorithms and data structures; Random(ized) Search Trees, Point Location, Minimum Cut, Linear Programming, Randomized Algebraic Algorithms (matchings), Probabilistically Checkable Proofs (introduction).

Studying and understanding of fundamental concepts in algorithms, data structures and complexity theory.

Will be handed out.


Core Courses: Applied Mathematics and Further Appl.- Oriented Fields (Mathematics Master)

Core Courses: Further Application-Oriented Fields

For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>C. Anastasiou</td>
</tr>
</tbody>
</table>

Abstract

Objective
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

Content
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.

Lecture notes
Auf Moodle

Literature
G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking not assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Electives

Selection: Algebra, Number Thy, Topology, Discrete Mathematics, Logic

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

Abstract
Does not take place this semester.

Objective
Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content
Counts of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Burnside's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3034-00L</td>
<td>Axiomatic Set Theory</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U</td>
<td>L. Halbeisen</td>
</tr>
</tbody>
</table>

Abstract

Content

Lecture notes
Ich werde mich weitgehend an mein Buch "Axiomatic Set Theory" (2nd ed., erscheint im Herbst 2017) halten.

Literature
"Axiomatic Set Theory: with a gentle introduction to forcing" (Springer-Verlag 2012)


Selection: Geometry

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1663 of 2345
### Finite Geometries I, II (6 credits)

**Objective**
Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

**Content**
Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design.

**Literature**
- Max Jeger, Endliche Geometrien, ETH Skript 1988
- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983
- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press

**Number** 401-3057-00L
**Title** Finite Geometries II
**Type** W
**ECTS** 4
**Hours** 2G
**Lecturers** N. Hungerbühler

### Topology of Manifolds (6 credits)

**Abstract**
This will be an introduction to geometric topology, a field of mathematics concerned with topological properties of manifolds. We will study both topological and smooth manifolds, and prove some fundamental results about them (like the Schoenflies theorem, the generalised Poincaré conjecture, the existence of exotic smooth structures), several of which have been awarded with Fields medals.

**Objective**
At the end of the course students will be able to differentiate between three types of manifolds, give examples showing various phenomena, and prove some classical results. They will understand what kinds of arguments are used in each of the cases, and where the difficulties arise. Moreover, they will become familiar with many open problems that are guiding current research, especially in the peculiar dimension four.

**Content**
There are several notions of a manifold -- namely, topological, piecewise-linear, and smooth -- and only in 1956 did it become clear that these objects are in fact distinct, thanks to the construction by J. Milnor of multiple smooth structures on a single topological manifold. In this course we will start with basic definitions and properties of the three types of manifolds, building our way up to cover some fundamental results.

We will first study decompositions, transversality and the Whitney trick, the s-cobordism theorem, the Poincaré conjecture, and the Schoenflies theorem. Possible further topics include torus tricks, smoothing theory, exotic spheres, the Rohlin theorem, exotic 4-manifolds.

**Literature**
- See the lecture notes and a reference list at https://maths.dur.ac.uk/users/mark.a.powell/topological-manifolds.html

**Prerequisites / notice**
We will assume familiarity with point-set topology, the fundamental group (as covered in the course Topology), homology (as covered in Algebraic Topology I), and some basics of differential topology and vector bundles (as covered in Differential Geometry I). Some familiarity with cohomology and Poincaré duality would be useful.

### High-Dimensional Statistics (4 credits)

**Abstract**
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

**Objective**
Knowledge of methods and basic theory for high-dimensional statistical inference

**Content**
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

**Literature**

**Prerequisites / notice**
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

**Number** 401-3627-00L
**Title** High-Dimensional Statistics
**Type** W
**ECTS** 4
**Hours** 2V
**Lecturers** P. L. Bühlmann

### Time Series Analysis (4 credits)

**Abstract**
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARIMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

**Objective**
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

**Content**
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered are:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARIMA, ARIMA, Introduction into GARCH models

**Literature**
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

**Number** 401-4623-00L
**Title** Time Series Analysis
**Type** W
**ECTS** 4
**Hours** 2G
**Lecturers** N. Meinshausen
Prerequisites / notice

### 401-0625-01L Applied Analysis of Variance and Experimental Design

**Abstract**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Objective**
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

**Taught competencies**

<table>
<thead>
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**Literature**

- Faraway (2005): Linear Models with R
- Faraway (2006): Extending the Linear Model with R
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Introduction to Linear Regression Analysis

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

### 401-0649-00L Applied Statistical Regression

**Abstract**
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

**Lecture notes**
A script will be available.

**Literature**

- Faraway (2005): Linear Models with R
- Faraway (2006): Extending the Linear Model with R
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
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- Montgomery et al. (2006): Introduction to Linear Regression Analysis
- Montgomery et al. (2006): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Extending the Linear Model with R
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Introduction to Linear Regression Analysis

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

### 401-3622-00L Bayesian Statistics

**Abstract**
Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.

**Objective**
Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.

**Content**
Topics that we will discuss are:
- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)

**Lecture notes**
A script will be available in English.

**Literature**


**Prerequisites / notice**
Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.
Concepts and Theories

Reinsurance Analytics
M. Koller

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Non-Life Insurance: Mathematics and Statistics
M. V. Wüthrich

The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

Life Insurance Mathematics
M. Koller

The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

Mathematical Modelling in Life Insurance
M. V. Wüthrich

The following topics are treated:
- Collective Risk Modeling
- Individual Claim Size Modeling
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tariffication
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

The course counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Mathematical Modelling in Life Insurance
M. V. Wüthrich

The course’s objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn to price embedded options in life insurance. Aside of the mere application of specific models, they should develop an intuition for the various drivers of the value of these options.

Reinsurance Analytics
M. Koller

The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

In the Bachelor’s programme in Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course, but only if 401-3889-00L Introduction to Mathematical Finance isn’t recognised for credits (neither in the Bachelor’s nor in the Master’s programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.
This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical

- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

Lecture notes Slides and lecture notes will be made available.

An excerpt of last year's lecture notes is available here: https://sites.google.com/site/philipparbenz/reinsuranceanalytics

Prerequisites / notice Basic knowledge in statistics, probability theory, and actuarial techniques.

Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Responsible Machine Learning with Insurance Applications

Objective
The student is familiar with the main tools of model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

Content
- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

Prerequisites / notice
This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Selection: Mathematical Physics, Theoretical Physics

Number Title Type ECTS Hours Lecturers
402-0830-00L General Relativity Special Students UZH must book the module PHYS11 directly at UZH.

Abstract
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.

Objective
Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).
### Content

Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

### Literature

Suggested textbooks:

- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll: Spacetime and Geometry: An Introduction to General Relativity
- S. Weinberg - Gravitation and Cosmology
- R. Wald: General Relativity
- S. Carroll: Spacetime and Geometry: An Introduction to General Relativity
- C. Misner, K. Thorne and J. Wheeler: Gravitation

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### Selection: Mathematical Optimization, Discrete Mathematics

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
401-3055-64L | Algebraic Methods in Combinatorics | W | 6 credits | 2V+1U | B. Sudakov

**Abstract**

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments. 
- Spaces of polynomials and tensor product methods.
- Eigenvalues of graphs and their application.
- The best combinatorial Nullstellensatz and the Chevalley-Warning theorem. 
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

**Lecture notes**

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

**Prerequisites / notice**

Students are expected to have a mathematical background and should be able to write rigorous proofs.

---

### Framework: Theoretical Computer Science

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
252-0417-00L | Randomized Algorithms and Probabilistic Methods | W | 10 credits | 3V+2U+4A | A. Steger

**Abstract**

Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

**Objective**

After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**

Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Lecture notes**

Yes.

**Literature**


---

252-1425-00L | Geometry: Combinatorics and Algorithms | W | 8 credits | 3V+2U+2A | B. Gärtner, E. Welzl, M. Hoffmann

**Abstract**

Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

**Objective**

The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains.

In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

**Content**

Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the triangulation theorem, convexity in Rd, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.
Lecture notes

Yes

Literature


Prerequisites / notice

Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

Selection: Further Realms and Some UZH Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0000-00L</td>
<td>Communication in Mathematics</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>not available</td>
</tr>
<tr>
<td>Abstract</td>
<td>Don't hide your Next Great Theorem behind bad writing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Knowing how to present written mathematics in a structured and clear manner.</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Topics covered include:</td>
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<tr>
<td></td>
<td>- Language conventions and common errors.</td>
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<tr>
<td></td>
<td>- How to write a thesis (more generally, a mathematics paper).</td>
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<td></td>
<td>- How to use LaTeX.</td>
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<td></td>
<td>- How to write a personal statement for Masters and PhD applications.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>There are no formal mathematical prerequisites.</td>
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</tbody>
</table>

401-3502-72L Reading Course

To start an individual reading course, contact an authorised supervisor
https://www.ethz.ch/content/dam/ethz/special-interest/mathematics/department/Intranet/Students/Theses_Reading_Courses/berechtigungsliste.pdf
and register your reading course in myStudies.

Abstract

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

401-3503-72L Reading Course

To start an individual reading course, contact an authorised supervisor
https://www.ethz.ch/content/dam/ethz/special-interest/mathematics/department/Intranet/Students/Theses_Reading_Courses/berechtigungsliste.pdf
and register your reading course in myStudies.

Abstract

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

401-3504-72L Reading Course

To start an individual reading course, contact an authorised supervisor
https://www.ethz.ch/content/dam/ethz/special-interest/mathematics/department/Intranet/Students/Theses_Reading_Courses/berechtigungsliste.pdf
and register your reading course in myStudies.

Abstract

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

263-5300-00L Guarantees for Machine Learning

Number of participants limited to 30.

Abstract

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

**Prerequisites / notice**

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH).

**Taught competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Analytical Competencies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Creative Thinking
- Critical Thinking

**401-8815-72L Mathematical Aspects of Quantum Mechanics (University of Zurich)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: MAT631

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

**Abstract**

The course aims at presenting the basic theory of Quantum Mechanics from the mathematical point of view.

No prior knowledge of Quantum Mechanics is required, and the language and tools necessary to develop the theory will be explicitly introduced.

**Objective**

After the course students should have learned topics of spectral theory for unbounded operators and the description of simple models of one-particle quantum systems.

**Content**

We will start with the main mathematical tools of QM: the theory of Hilbert spaces and unbounded operators, self-adjoint and unitary operators, and the spectral theorem. The standard axiomatic description of Quantum Mechanics, main motivation behind the above topics, will also be presented and discussed. This will be followed by the analysis of simple models of one-particle systems such as the free particle, the harmonic oscillator, and the hydrogen atom. Further topics as conservation laws and the angular momentum operators will also be discussed.

If time permits, we will also touch more advanced topics, as for example the theory of general Schrödinger operators and the semiclassical approximation.

**Literature**

- Lecture note written by Benjamin Schlein for the course MAT631 Mathematical Aspects of Quantum Mechanics for the Spring Semester 2018
- Schmüdgen – Unbounded Self-adjoint Operators on Hilbert Space
- Teta - A Mathematical Primer on Quantum Mechanics

**Prerequisites / notice**

The prerequisites are real analysis, and linear algebra. Basic knowledge of classical physics, operator theory on Hilbert spaces, and the Fourier transform are helpful but not required.

**401-8571-72L Differential Forms in Algebraic Topology (University of Zurich)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: MAT736

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

**Abstract**

This class will focus on those spaces that have a structure of differentiable manifolds and will use, as primary tools, differential forms on them. As a first example of invariants we will consider the de Rham cohomology, namely, spaces of closed forms modulo exact forms.

**Objective**

Understanding the basic concepts and applying them to a variety of situations.

**Content**

Algebraic topology consists of algebraic methods devoted to the problem of distinguishing nonhomeomorphic topological spaces (an example of this is the fundamental group discussed in the class Topology). This class will focus on those spaces that have a structure of differentiable manifolds and will use, as primary tools, differential forms on them. As a first example of invariants we will consider the de Rham cohomology, namely, spaces of closed forms modulo exact forms.

This approach is "less elementary" than others, as it requires the notions of differentiable manifold and of differential form and as it uses integration as an essential tool. On the other hand, for those that are already familiar with these concepts, it provides a more intuitive approach. Moreover, several results are of direct importance to applications, e.g., in physics.

**Literature**


**Prerequisites / notice**

Prior knowledge: linear algebra and analysis. A basic knowledge of topology and algebra is useful. Differentiable manifolds and differential forms will be quickly reviewed at the beginning of the course, but a previous exposure is beneficial.

**Core Courses and Electives (Mathematics Master)**

Core Courses (Mathematics Master)

Electives (Mathematics Master)
Seminars

NOTICE: The number of seminar places is limited, and the special selection procedure should help to allocate the places not primarily according to the registration time. Everybody is waitlisted first when he/she tries to register for a seminar in myStudies. Moreover: Only one mathematics seminar can be chosen per semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3550-72L</td>
<td>Topology and Combinatorics of Zero Sets of Polynomials in the Plane</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>P. Feller</td>
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<tr>
<td></td>
<td>Number of participants limited to 24.</td>
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<tr>
<td>Literature</td>
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<tr>
<td>Prerequisites /</td>
<td>&quot;A singular mathematical promenade&quot; by Étienne Ghys.</td>
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<tr>
<td>notice</td>
<td>Requirements (beyond first year Bachelor courses):</td>
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<tr>
<td></td>
<td>- One semester introduction to complex analysis (as provided by D-Math's &quot;Funktionentheorie&quot;)</td>
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<tr>
<td></td>
<td>- One semester introduction to topology (as provided by D-Math's &quot;Topologie&quot;)</td>
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<tr>
<td>401-3680-72L</td>
<td>Persistent Homology</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>not available</td>
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<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td>401-3350-72L</td>
<td>Elliptic Partial Differential Equations</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>F. Da Lio, L. Keller</td>
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<td>Number of participants limited to 12.</td>
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<tr>
<td>401-4350-72L</td>
<td>Introduction to Partial Differential Equations</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
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<td></td>
<td>Number of participants limited to 24.</td>
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<tr>
<td>401-3760-72L</td>
<td>Topics in Fluid Dynamics</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
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<td>Number of participants limited to 12.</td>
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<tr>
<td>401-3940-72L</td>
<td>Student Seminar in Mathematics and Data: Differential Privacy</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>A. Bandeira</td>
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<td>Number of participants limited to 12.</td>
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<tr>
<td>401-3620-20L</td>
<td>Student Seminar in Statistics: Inference in Some Non-Standard Regression Problems</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>F. Balabdaoui</td>
</tr>
<tr>
<td></td>
<td>Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics. Also offered in the Master Programmes Statistics resp. Data Science.</td>
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<tr>
<td>Abstract</td>
<td>Review of some non-standard regression models and the statistical properties of estimation methods in such models.</td>
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<tr>
<td>Objective</td>
<td>The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).</td>
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<tr>
<td>Content</td>
<td>Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, linearity might be too simplistic to capture the actual relationship between some response and given covariates. Also, there are many real data problems where linearity is plausible but the actual pairing between the observed covariates and responses is completely lost or at partially. In this seminar, we review some of the non-classical regression models and the statistical properties of the estimation methods considered by well-known statisticians and machine learners. This will encompass:</td>
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<tr>
<td></td>
<td>1. Monotone regression</td>
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<td>2. Single index model</td>
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<td></td>
<td>3. Unlinked regression</td>
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<tr>
<td>Literature</td>
<td>In the following is the tentative material that will be read and studied by each pair of students (all the items listed below are available through the ETH electronic library or arXiv). Some of the items might change.</td>
<td></td>
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<td></td>
<td>8. &quot;Linear regression with shuffled data: statistical and computation limits of permutation recovery&quot; by A. Pananjady, M. Wainwright and T. A. Courtade , 2018, IEEE transactions in Information Theory, Volume 64, 3296-3300</td>
<td></td>
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<td></td>
<td>9. &quot;Linear regression without correspondence&quot; by D. Hsu, K. Shi and X. Sun, 2017, NIPS</td>
<td></td>
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<tr>
<td></td>
<td>11. &quot;Uncoupled isotonic regression via minimum Wasserstein deconvolution&quot; by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27</td>
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<tr>
<td></td>
<td>The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.</td>
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<tr>
<td>Prerequisites /</td>
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<tr>
<td>notice</td>
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<tr>
<td>401-3650-72L</td>
<td>Rational Approximation and Interpolation</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>R. Hiptmair</td>
</tr>
<tr>
<td>Abstract</td>
<td>The seminar covers theory and algorithms for rational interpolation based on classical and modern literature. The various topics have to be presented by groups of students.</td>
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</tbody>
</table>
Objective
Participants of the seminar should acquire familiarity with the theoretical properties of approximation by means of rational functions as well as knowledge about algorithms used for computing approximating or interpolating rational functions.

Prerequisites / notice
Good skills in analysis are required as well as basic familiarity with numerical methods for interpolation and approximation with polynomials.

Every presentation has to be done jointly by a group of 2-3 students with presenters selected at random. Every participant will have to present on 2-3 occasions.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Cooperation and Teamwork</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
</tr>
</tbody>
</table>

401-3050-72L Student Seminar in Combinatorics

Number of participants limited to 12.

Abstract
The seminar will consist of student presentations and will cover a variety of topics in modern-day combinatorics. The seminar is aimed at third year bachelor students or master students with a background in combinatorics (e.g. the Graph Theory course).

Objective
The seminar's aim is to acquaint students with interesting results, proofs and techniques in combinatorics and graph theory, and to give them the opportunity to work with advanced research papers and practice their presentation skills.

☑️ Bachelor’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Mathematics</td>
<td>O</td>
<td>0</td>
<td></td>
<td>D. Possamaï</td>
</tr>
<tr>
<td></td>
<td>Target audience: Third year Bachelor students; Master students who cannot document to have received an adequate training in working scientifically.</td>
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</tbody>
</table>

Abstract
Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)

Objective
Learn the basic standards of scientific works in mathematics.

Content
- Types of mathematical works
- Publication standards in pure and applied mathematics
- Data handling
- Ethical issues
- Citation guidelines

Prerequisites / notice

401-2000-01L Lunch Sessions – Thesis Basics for Mathematics

Students
Details and registration for the optional MathBib training course: https://www.math.ethz.ch/mathbib-schulungen

Abstract
Optional MathBib training course

401-3990-10L Bachelor’s Thesis

Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics is required. For more information, see www.math.ethz.ch/intranet/students/study-administration/theses.html

Abstract
The purpose of the BSc thesis is to deepen knowledge in a certain subject chosen by the student. In their BSc thesis, students should demonstrate their ability to carry out independent work in mathematics and to organize results in a written report.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MATH

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>R. Abgrall, M. Iacobelli, A. Bandeira, A. Iozzi, S. Mishra, R. Pandharipande, University lecturers</td>
</tr>
<tr>
<td>401-5990-00L</td>
<td>Zurich Graduate Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>A. Iozzi, further speakers</td>
</tr>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>N. Hungerbühler, M. Akved, D. Grawehr Morath, J. Hromkovic, P. Spindler</td>
</tr>
</tbody>
</table>

Subject didactics for mathematics and computer science

Data: 18.08.2022 12:39   Autumn Semester 2022   Page 1672 of 2345
<table>
<thead>
<tr>
<th>Course ID</th>
<th>Name</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
<tr>
<td>402-0800-00L</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>J. Renes, University lecturers</td>
</tr>
<tr>
<td>251-0100-00L</td>
<td>Computer Science Colloquium</td>
<td>E-</td>
<td>0</td>
<td>2K</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

**Objective**
The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.

The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.

Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.

Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department’s professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.

Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

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**Mathematics Bachelor - Key for Type**

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tr>
<tr>
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<td>practical/laboratory course</td>
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</tr>
<tr>
<td>A</td>
<td>independent project</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
<td></td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**Mathematics TC**

**Detailed information on the programme at:** [www.ethz.ch/didaktische-ausbildung](http://www.ethz.ch/didaktische-ausbildung)

### Educational Science

General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>U. Markwalder</td>
</tr>
</tbody>
</table>

**Abstract**

The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

**Objective**

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

**Content**

Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

### Subject Didactics and Professional Training

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

**Enrolment in either Mathematics Didactics I or Mathematics Didactics II (spring semester) is compulsory.**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3971-11L</td>
<td>Mathematics Didactics I</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>A. Barth</td>
</tr>
</tbody>
</table>

**Abstract**

Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching various topics in mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

**Objective**

- Students use their specialist-subject, educational-science and subject didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

**Content**

The Studierenden sammeln Erfahrungen in der Unterrichtsführung, der Auseinandersetzung mit Lernenden, der Klassenbetreuung und der Formations of Knowledge in STEM Fields in Primary and Secondary School. Addresses to students enrolled either in Teaching Diploma (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport). This course unit can only be enrolled after successful participation in the course 851-0240-00L “Human Learning (EW 1)”.

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

**Lectures**

- Dokument: schriftliche Vorbereitung für Prüfungsaufgaben.
- Wird von der Praktikumslehrperson bestimmt.

**Literature**

- [Autumn Semester 2022](#)
- [Page 1674 of 2345](#)
Objective

The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Thematische Schwerpunkte
Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen

Literature
Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.

Literatur
Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3057-00L</td>
<td>Finite Geometries II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler’s thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>- Max Jeger, Endliche Geometrien, ETH Skript 1988</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press</td>
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<tr>
<td></td>
<td>- Dembowski: Finite Geometries.</td>
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</tbody>
</table>

| 401-3059-00L| Combinatorics II | W | 4 credits | 2G | N. Hungerbühler |
| Abstract    | Does not take this semester. |
| Objective   | The course Combinatorics I and II is an introduction into the field of enumerative combinatorics. |
| Content     | Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler’s function, Cayley graphs, formal power series, permutation groups, cycles, Bunside’s lemma, cycle index, Polya’s theorems, applications to graph theory and isomers. |

| 401-0293-00L| Mathematics III | W | 5 credits | 3V+2U | A. Caspar, N. Hungerbühler |
| Objective   | Die Studierenden |
|             | verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften. |
|             | können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenfalls explizit berechnen: diskret/kontinuierlich in Zeit, Ebene und Raum. |
|             | können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten. |
**Content**

- Einführung Modellbildung
  - SIR-Modelle
  - Pocken-Modell

Lineare Modelle

- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen

- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle

- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen

- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Laplace-Transformation

- Definition und Notation
- Rechenregeln
- Anwendungsbeispiele

**Lecture notes**

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar and N. Hungerbühler

**Literature**

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

**Prerequisites / notice**

Vorlesungen Mathematik I/II

**Taught competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Cooperation and Teamwork
- Personal Competencies: Creative Thinking

**Prerequisites / notice**

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

**Colloquia**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education Subject didactics for mathematics and computer science teachers.</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>N. Hungerbühler, M. Akveld, D. Grawehr Morath, J. Hromkovic, P. Spindler</td>
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</table>
## Mathematics TC - Key for Type

<table>
<thead>
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<th>Key</th>
<th>Description</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td></td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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## Key for Hours

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<tbody>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
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**ECTS**
European Credit Transfer and Accumulation System

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Mathematics Teaching Diploma

Details information on the programme at: www.ethz.ch/didaktische-ausbildung

Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

see Educational Science Teaching Diploma

Subject Didactics in Mathematics

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3971-11L</td>
<td>Mathematics Didactics I</td>
<td>O</td>
<td>4</td>
<td>2G</td>
<td>A. Barth</td>
</tr>
<tr>
<td></td>
<td><em>Enrolment only possible with matriculation in Mathematics Teaching Diploma or Mathematics TC at ETH or in Mathematics Teaching Diploma at UZH.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching various topics in mathematics. Methodological suggestions are compared and draft tuition concepts discussed.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>On the basis of their understanding of mathematics, of the knowledge acquired from research into teaching/learning and subject teaching, and also of best practice, students who have completed this course will be in a position to draft motivating learning arrangements, with cognitive appeal, which trigger and maintain learning processes. The aim here is to implement a corresponding teaching plan, so that the mathematics tuition that is given has a general-education value, on the one hand, and ensures that pupils acquire the fundamental knowledge necessary for studying at university, on the other hand.</td>
</tr>
<tr>
<td>401-9983-00L</td>
<td>Mentored Work Subject Didactics Mathematics A</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>M. Akveld, A. Barth, L. Halbeisen, N. Hungerbühler, C. Rüede</td>
</tr>
<tr>
<td></td>
<td><em>Mentored Work Subject Didactics in Mathematics for TC and Teaching Diploma.</em></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>The objective is for the students: - to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too. - to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.</td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td></td>
<td></td>
<td></td>
<td>Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.</td>
</tr>
<tr>
<td>401-9984-00L</td>
<td>Mentored Work Subject Didactics Mathematics B</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>M. Akveld, A. Barth, L. Halbeisen, N. Hungerbühler, C. Rüede</td>
</tr>
<tr>
<td></td>
<td><em>Mentored Work Subject Didactics in Mathematics for Teaching Diploma and for students upgrading TC to Teaching Diploma.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>Objective</td>
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</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td></td>
<td></td>
<td></td>
<td>Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.</td>
</tr>
</tbody>
</table>

Professional Training in Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-9970-00L</td>
<td>Introductory Internship Mathematics</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td></td>
<td><em>Enrolment only possible with matriculation in Mathematics Teaching Diploma or Mathematics TC at ETH.</em> It is advisable to enrol in this course not prior to the first Mathematics Didactics course and not after the second Mathematics Didactics course.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1678 of 2345
During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice. 

Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training. 

Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Prerequisites / notice
This course is to be chosen jointly with 401-3972-00L.

Objective
- Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Content
- The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Abstract
Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Literature
Wird von der Praktikumslehrperson bestimmt.

Prerequisites / notice
This course is to be chosen jointly with 401-3972-00L.

Objective
- The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.
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- Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Abstract
Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Literature
Wird von der Praktikumslehrperson bestimmt.

Prerequisites / notice
This course is to be chosen jointly with 401-3972-00L.

Objective
- The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content
- Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Abstract
Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

Literature
Wird von der Praktikumslehrperson bestimmt.

Prerequisites / notice
This course is to be chosen jointly with 401-3972-00L.

Objective
- The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
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Wird von der Praktikumslehrperson bestimmt.

Prerequisites / notice
This course is to be chosen jointly with 401-3972-00L.
### Contents


Die gehaltene Lektion wird kriteri umsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltene Lektion im Rahmen eines kurzen Kolloquiums.

### Lecture notes

Dokument: Schriftliche Vorbereitung für Prüfungslektionen

Nach Abschluss der übrigen Ausbildung.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-9991-02L</td>
<td>Examination Lesson II Mathematics</td>
<td>O</td>
<td>1</td>
<td>2P</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in &quot;Examination Lesson I Mathematics&quot; (401-9991-01L) is compulsory.</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.</td>
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<td>Objective</td>
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<td>On the basis of a specified topic, the candidate shows that they are in a position to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle</td>
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<td>- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.</td>
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<td></td>
<td>Content</td>
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<td></td>
<td>Lecture notes</td>
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<td></td>
<td>Dokument: Schriftliche Vorbereitung für Prüfungslektionen</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td>Nach Abschluss der übrigen Ausbildung.</td>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.</td>
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<td>Content</td>
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<tr>
<td></td>
<td>Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsides's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.</td>
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<tr>
<td>401-3057-00L</td>
<td>Finite Geometries II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.</td>
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<td>Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.</td>
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<td></td>
<td>Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design</td>
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<td></td>
<td>Literature</td>
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<td></td>
<td>- Max Jeger, Endliche Geometrien, ETH Skript 1988</td>
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<td></td>
<td>- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983</td>
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<td></td>
<td>- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press</td>
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<td>- Dembowski: Finite Geometries.</td>
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<tr>
<td>401-0293-00L</td>
<td>Mathematics III</td>
<td>W</td>
<td>5</td>
<td>3V+2U</td>
<td>A. Caspar, N. Hungerbühler</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td>Vertiefung der mehrdimensionalen Analysis mit Schwerpunkt in der Anwendung der partiellen Differentialgleichungen, Vertiefung der Linearen Algebra und Einführung in die Systemanalyse und Modellbildung.</td>
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<td>Objective</td>
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</tbody>
</table>
Content

Einführung Modellbildung
- SIR-Modelle
- Pocken-Modell

Lineare Modelle
- Vektorräume
- Lösungsräume eines linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen
- Euklidische Vektorräume
- Orthogonale Projektion

Nichtlineare Modelle
- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen
- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Lecture notes

Buch: “Mathematische Modellbildung in den Life Sciences”, A. Caspar und N. Hungerbühler
- Buch: “Mathematische Modellbildung in den Life Sciences”, A. Caspar und N. Hungerbühler

Literature

Prerequisites / notice

Vorlesungen Mathematik I/II

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Cooperation and Teamwork assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

401-9985-00L Mentored Work Specialised Courses in the Respective O
Subject with an Educational Focus Mathematics A
Mentored Work Specialised Courses in the Respective Subject with an Educational Focus in Mathematics for TC and Teaching Diploma.

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content

Thematische Schwerpunkte:

Lernformen:

Lecture notes
Eine Anleitung zur mentorisierten Arbeit in FV wird zur Verfügung gestellt.

Literature
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

401-9986-00L Mentored Work Specialised Courses in the Respective O
Subject with an Educational Focus Mathematics B
Mentored Work Specialised Courses in the Respective Subject with an Educational Focus in Mathematics for Teaching Diploma and for students upgrading TC to Teaching Diploma.

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
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- To try out different options for specialist further training in their profession.

Content

Thematische Schwerpunkte:

Lernformen:

Lecture notes
Eine Anleitung zur mentorisierten Arbeit in FV wird zur Verfügung gestellt.

Literature
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.
The general goal of the course consists in presenting ways to teach fundamentals of computer science, which are closely related to computer science in secondary school mathematics. The main topics of the course unit "Computer Science in Secondary School Mathematics" represent a scientific and didactic added value.

Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsen's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design.

The students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

The students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

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The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

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The unit "Computer Science in Secondary School Mathematics" addresses key contributions of computer science to general education, the didactics of logic, of cryptology, of finite state automata, of computability and of the introduction to programming.

The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.
### Literature

J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen" Lehrwerksreihe "Einfach Informatik"

[https://einfachinformatik.inf.ethz.ch/](https://einfachinformatik.inf.ethz.ch/)


*see Compulsory Elective Courses Teaching Diploma*

### Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education Subject didactics for mathematics and computer science teachers.</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>N. Hungerbühler, M. Akveld, D. Grawehr Morath, J. Hromkovic, P. Spindler</td>
</tr>
</tbody>
</table>

**Abstract**
Didactics colloquium

### Mathematics Teaching Diploma - Key for Type

- **O** Compulsory
- **E-** Recommended, not eligible for credits
- **W+** Eligible for credits and recommended
- **W** Eligible for credits
- **Z** Courses outside the curriculum
- **Dr** Suitable for doctorate

### Key for Hours

- **V** lecture
- **P** practical/laboratory course
- **G** lecture with exercise
- **A** independent project
- **U** exercise
- **D** diploma thesis
- **S** seminar
- **R** revision course / private study
- **K** colloquium

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
For the Master's degree in Applied Mathematics the following additional condition (not manifest in myStudies) must be obeyed: At least 15 of the required 28 credits from core courses and electives must be acquired in areas of applied mathematics and further application-oriented fields.

### Core Courses: Pure Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>401-3225-00L</td>
<td>Introduction to Lie Groups</td>
<td>W</td>
<td>8 credits</td>
<td>4G</td>
<td>M. Burger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Topological groups and Haar measure. Definition of Lie groups, examples of local fields and examples of discrete subgroups; basic properties; Lie subgroups. Lie algebras and relation with Lie groups: exponential map, adjoint representation. Semisimplicity, nilpotency, solvability, compactness: Killing form, Lie's and Engel's theorems. Definition of algebraic groups and relation with Lie groups.</td>
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<tr>
<td>Objective</td>
<td>The goal is to have a broad though foundational knowledge of the theory of Lie groups and their associated Lie algebras with an emphasis on the algebraic and topological aspects of it.</td>
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</tr>
</tbody>
</table>
| Literature | A. Knapp: "Lie groups beyond an Introduction" (Birkhaeuser)  
A. Sagle & R. Walde: "Introduction to Lie groups and Lie algebras" (Academic Press, '73)  
F. Warner: "Foundations of differentiable manifolds and Lie groups" (Springer)  
H. Samelson: "Notes on Lie algebras" (Springer, '90)  
S. Helgason: "Differential geometry, Lie groups and symmetric spaces" (Academic Press, '78)  
| Prerequisites / notice | Topology and basic notions of measure theory. A basic understanding of the concepts of manifold, tangent space and vector field is useful, but could also be achieved throughout the semester. |

401-3001-61L  
**Algebraic Topology I**  
*W*  
8 credits  
4G  
S. Kalisnik Hintz  
Abstract  
This is an introductory course in algebraic topology, which is the study of algebraic invariants of topological spaces. Topics covered include: singular homology, cell complexes and cellular homology, the Eilenberg-Steenrod axioms.  
Literature  
Book can be downloaded for free at: http://www.math.cornell.edu/~hatcher/AT/ATpage.html  
See also: http://www.math.cornell.edu/~hatcher/anchor1772800  
3) E. Spanier, "Algebraic topology", Springer-Verlag  
You should know the basics of point-set topology.  
Prerequisites / notice  
Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course "topology"). Some knowledge of differential geometry and differential topology is useful but not strictly necessary. Some (elementary) group theory and algebra will also be needed.  

401-3132-00L  
**Commutative Algebra**  
*W*  
10 credits  
4V+1U  
S. Zerbes  
Abstract  
Does not take place this semester.  
Not offered in the Autumn Semester 2022.  
Objective  
The topics presented in the course will include:  
* Basics facts about rings, ideals and modules  
* Constructions of rings: quotients, polynomial rings, localization  
* Noetherian rings and modules  
* The tensor product of modules over commutative rings and its applications  
* Krull dimension  
* Integral extensions and the Cohen-Seidenberg theorems  
* Finitely generated algebras over fields, including the Noether Normalization Theorem and the Nullstellensatz  
* Primary decomposition  
* Discrete valuation rings and some applications  
Literature  
Primary Reference:  
Secondary References:  
2. "Commutative Algebra, With a view towards algebraic geometry" by D. Eisenbud (GTM 150, Springer Verlag, 1995)  
4. "Commutative Algebra" by N. Bourbaki  
Prerequisites / notice  
Prerequisites: Algebra I/II (or a similar introduction to the basic concepts of ring theory, including field theory).  

401-3111-72L  
**Number Theory I**  
*W*  
8 credits  
4G  
S. Zerbes  
Abstract  
This course will give an introduction to the theory of number fields, which are fundamental objects in algebraic number theory.
Objective

In this course, we will cover the following topics:
- review of field extensions, algebraic numbers
- rings of integers, discriminants, integral bases
- examples: cyclotomic fields
- non-unique factorisation of algebraic integers, unique factorisation into prime ideals
- fractional ideals, class groups
- lattices and Minkowski's lemma, finiteness of the class group
- computations of the class number
- group of units of a number field
- Dedekind zeta functions, class number formula

Literature


Neukirch, Algebraic Number Theory, Springer

Prerequisites / notice

Galois theory

401-8141-00L Algebraic Geometry (University of Zurich) W 9 credits 3V+2U University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH. UZH Module Code: MAT507

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

A related course is 401-3146-12L Algebraic Geometry. Although both courses can be taken independently of each other, only one will be recognised for credits in the Bachelor and Master degree. In particular, it is not allowed to earn credit points with one for the Bachelor and with the other for the Master degree.

Abstract

Projective varieties, projective geometry, schemes.

Objective

To acquire familiarity with basic properties of projective varieties; some scheme theory.

Core Courses: Applied Mathematics and Further Appl.-Oriented Fields

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>401-3651-00L</td>
<td>Numerical Analysis for Elliptic and Parabolic Partial Differential Equations</td>
<td>W</td>
<td>9</td>
<td>4V+1U</td>
<td>H. Ammari</td>
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</tbody>
</table>

3rd year ETH BSc Mathematics and MSc Mathematics and MSc Applied Mathematics students. Other ETH-students are advised to attend the course "Numerical Methods for Partial Differential Equations" (401-0674-00L) in the CSE curriculum during the spring semester.

Abstract

This course gives a comprehensive introduction into the numerical treatment of linear and nonlinear elliptic boundary value problems, related eigenvalue problems and linear, parabolic evolution problems. Emphasis is on theory and the foundations of numerical methods. Practical exercises include MATLAB implementations of finite element methods.

Objective

Participants of the course should become familiar with

* concepts underlying the discretization of elliptic and parabolic boundary value problems
* analytical techniques for investigating the convergence of numerical methods for the approximate solution of boundary value problems
* methods for the efficient solution of discrete boundary value problems
* implementation aspects of the finite element method

Content

The course will address the mathematical analysis of numerical solution methods for linear and nonlinear elliptic and parabolic partial differential equations. Functional analytic and algebraic (De Rham complex), tools will be provided. Primal, mixed and nonstandard (discontinuous Galerkin, Virtual, Trefftz) discretizations will be analyzed. Particular attention will be placed on developing mathematical foundations (Regularity, Approximation theory) for a-priori convergence rate analysis. A-posteriori error analysis and mathematical proofs of adaptivity and optimality will be covered. Implementations for model problems in MATLAB and python will illustrate the theory.

A selection of the following topics will be covered:

* Elliptic boundary value problems
* Galerkin discretization of linear variational problems
* The primal finite element method
* Mixed finite element methods
* Discontinuous Galerkin Methods
* Boundary element methods
* Spectral methods
* Adaptive finite element schemes
* Singularly perturbed problems
* Sparse grids
* Galerkin discretization of elliptic eigenproblems
* Non-linear elliptic boundary value problems
* Discretization of parabolic initial boundary value problems
In der Regression wird die Abhängigkeit einer beobachteten quantitativen Größe von einer oder mehreren anderen (unter

4G


**Abstract**

The course covers the basics of inferential statistics.

**Objective**

Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

**Content**


This is the course unit with former course title "Regression". Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

**Abstract**

Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes)

**Objective**

Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes)

**Content**

This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- additional topics

**Literature**

Prerequisites are the standard courses
- Probability Theory (for which lecture notes are available)
- Brownian Motion and Stochastic Calculus (for which lecture notes are available)

Those students who already attended "Introduction to Mathematical Finance" will have an advantage in terms of ideas and concepts.

This course is the second of a sequence of two courses on mathematical finance. The first course "Introduction to Mathematical Finance" (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imfs/education/education-in-stochastic-finance/overview-of-courses.html.

**Abstract**

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Abstract**

The course covers the basics of inferential statistics.

**Objective**

Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

**Content**


This is the course unit with former course title "Regression". Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

**Abstract**

Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes)

**Objective**

Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes)

**Content**

This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- and probably others
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature

Prerequisites / notice
Solid background in linear algebra.

Bachelor Core Courses: Pure Mathematics

Further restrictions apply, but in particular:
401-3531-00L Differential Geometry I can only be recognised for the Master Programme if 401-3532-00L Differential Geometry II has not been recognised for the Bachelor Programme.
Analogously for:
401-3461-00L Functional Analysis I - 401-3462-00L Functional Analysis II
401-3001-61L Algebraic Topology I - 401-3002-12L Algebraic Topology II
401-3132-00L Commutative Algebra – 401-3146-12L Algebraic Geometry
For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>401-3461-00L</td>
<td>Functional Analysis I</td>
<td>E-</td>
<td>10 credits</td>
<td>4V+1U</td>
<td>P. Hintz</td>
</tr>
</tbody>
</table>

Abstract
- Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies, Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed range theorem; spectral theory of self-adjoint operators in Hilbert spaces.

Objective
- Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature

Prerequisites / notice
- Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and L^p spaces).
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are:

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces

Lecturers

<table>
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<tr>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability Theory</td>
<td>10</td>
<td>4V+1U</td>
<td>W. Werner</td>
</tr>
</tbody>
</table>

Abstract


Objective

Introduce the classical theory of curves and surfaces (which is the precursor of modern Riemannian geometry). Invite students to use and sharpen their geometric intuition.

Introduce the language, basic tools, and some fundamental results in modern differential geometry.

Lecture notes

Partial lecture notes are available from Prof. Lang's website https://people.math.ethz.ch/~lang/

Literature

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- John M. Lee: Introduction to Smooth Manifolds
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie. Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Bachelor Core Courses: Applied Mathematics ...

Further restrictions apply, but in particular:

- 401-3601-00L Probability Theory can only be recognised for the Master Programme if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.
- 402-0205-00L Quantum Mechanics I is eligible as an applied core course, but only if 402-0224-00L Theoretical Physics (offered for the last time in FS 2016) isn't recognised for credits (neither in the Bachelor's nor in the Master's programme).
- Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3601-00L</td>
<td>Probability Theory</td>
<td>E-</td>
<td>10</td>
<td>4V+1U</td>
<td>W. Werner</td>
</tr>
</tbody>
</table>

Abstract

Basics of probability theory and the theory of stochastic processes in discrete time

Objective

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes

will be available in electronic form.

Literature

- H. Bauer, Probability Theory, de Gruyter 1996
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- D. Williams, Probability with martingales, Cambridge University Press 1991

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>C. Anastasiou</td>
</tr>
</tbody>
</table>

Abstract


Objective

Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

Content

The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.

Lecture notes

Auf Moodle
Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of G. Jones and A. Wilkie: O-minimality and diophantine geometry, Cambridge University Press.

Electives

For the Master's degree in Applied Mathematics the following additional condition (not manifest in myStudies) must be obeyed: At least 15 of the required 28 credits from core courses and electives must be acquired in areas of applied mathematics and further application-oriented fields.

Electives: Pure Mathematics

Selection: Algebra, Number Thy, Topology, Discrete Mathematics, Logic

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
<td>&quot;Combinatorial Set Theory: with a gentle introduction to forcing&quot; (Springer-Verlag 2012)</td>
</tr>
</tbody>
</table>

Abstract

The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.

Objective

Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content

Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsol's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3034-00L</td>
<td>Axiomatic Set Theory</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U</td>
<td>L. Halbeisen</td>
<td></td>
</tr>
</tbody>
</table>

Abstract

The overall goal of this course is to provide an introduction to o-minimality and the applications of o-minimal structures.

Objective

The first part of the course will be devoted to an introduction to model theory as a framework in which to define o-minimal structures. The main result will be the "cell decomposition theorem", which describes the shape of definable subsets of an o-minimal structure. In the second part of the course, we will discuss examples of interesting o-minimal structures, and then consider applications to number theory. The course will include Pila-Wilkie counting theorem, or the Pila-Zannier strategy in the context of the Manin-Mumford conjecture.

Literature

G. Jones and A. Wilkie: O-minimality and diophantine geometry, Cambridge University Press.
L. van den Dries: Tame topology and o-minimal structures, Cambridge University Press.
A. Forey: lectures notes on o-minimality and arithmetic applications.

Prerequisites / notice

This course is appropriate for people with basic knowledge of abstract algebra and commutative algebra. Some knowledge of differential geometry, mathematical logic or some number theory is welcome, but not required.

Selection: Geometry

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3057-00L</td>
<td>Finite Geometries II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

Abstract

Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

Objective

Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.
For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent study.

At the end of the course students will be able to differentiate between three types of manifolds, give examples showing various phenomena, and prove some classical results. They will understand what kinds of arguments are used in each of the cases, and where the difficulties arise. Moreover, they will become familiar with many open problems that are guiding current research, especially in the peculiar dimension four.

There are several notions of a manifold -- namely, topological, piecewise-linear, and smooth -- and only in 1956 did it become clear that these objects are in fact distinct, thanks to the construction by J. Milnor of multiple smooth structures on a single topological manifold. In this course we will start with basic definitions and properties of the three types of manifolds, building our way up to cover some fundamental results.

We will first study handle decompositions, transversality and the Whitney trick, the s-cobordism theorem, the Poincaré conjecture, and the Schoenflies theorem. Possible further topics include torus tricks, smoothing theory, exotic spheres, the Rohlin theorem, exotic 4-manifolds.

**Literature**

- See the lecture notes and a reference list at [https://maths.dur.ac.uk/users/mark.a.powell/topological-manifolds.html](https://maths.dur.ac.uk/users/mark.a.powell/topological-manifolds.html)

**Prerequisites / notice**

We will assume familiarity with point-set topology, the fundamental group (as covered in the course Topology), homology (as covered in Algebraic Topology I), and some basics of differential topology and vector bundles (as covered in Differential Geometry I). Some familiarity with cohomology and Poincaré duality would be useful.

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**Selection: Analysis**

*No offering in this semester yet*

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**Selection: Further Realms and Some UZH Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0000-00L</td>
<td>Communication in Mathematics</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>not available</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Don't hide your Next Great Theorem behind bad writing.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Knowing how to present written mathematics in a structured and clear manner.</td>
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<tr>
<td>Content</td>
<td>Topics covered include:</td>
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<tr>
<td></td>
<td>- Language conventions and common errors.</td>
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<tr>
<td></td>
<td>- How to write a thesis (more generally, a mathematics paper).</td>
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<td></td>
<td>- How to use LaTeX.</td>
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<td></td>
<td>- How to write a personal statement for Masters and PhD applications.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>There are no formal mathematical prerequisites.</td>
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</tr>
</tbody>
</table>

| 401-3502-72L | Reading Course | W    | 2    | 4A    | Supervisors |
|             | To start an individual reading course, contact an authorised supervisor [https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf](https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf) and register your reading course in myStudies. |      |      |       |            |
| Abstract    | For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study. |      |      |       |            |

| 401-3503-72L | Reading Course | W    | 3    | 6A    | Supervisors |
|             | To start an individual reading course, contact an authorised supervisor [https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf](https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf) and register your reading course in myStudies. |      |      |       |            |
| Abstract    | For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study. |      |      |       |            |

| 401-3504-72L | Reading Course | W    | 4    | 9A    | Supervisors |
|             | To start an individual reading course, contact an authorised supervisor [https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf](https://www.ethz.ch/content/dam/ethz/special-interest/math/department/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf) |      |      |       |            |
| Abstract    | For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study. |      |      |       |            |
Generalized complex geometry is a modern approach to unify complex, symplectic, Poisson and more structures. All these can be understood as differentiable manifolds with additional geometric structures.

The goal is to develop an understanding of the foundations of generalized complex geometry, compare it with familiar geometric structures and study some applications.

Prior knowledge: smooth manifolds, complex geometry

• "Generalized Kähler Geometry of instanton moduli spaces" Bursztyn, Cavalcanti, Gualtieri
• "Reduction of Courant algebroids and generalized complex structures" Bursztyn, Cavalcanti, Gualtieri
• "Generalized complex geometry" Gualtieri

The aim of this course is to give an introduction to A¹-homotopy theory following Morel and Voevodsky. In particular, we will develop enough machinery to understand Morel’s computation of the homotopy groups of spheres in the so-called Milnor range. If time permits, we will see how they mediate between Lagrangian submanifolds with a flat bundle and complex submanifolds with a holomorphic reduction of complex manifolds.

Alternatively one can encode a generalized complex structure by its +i eigenbundle that forms a Dirac structure or as a pure spinor for the Clifford algebra of $T+T^*$. We will explore $T+T^*$ with its natural split signature metric, Courant bracket and its symmetries which are an extension of smooth diffeomorphisms. A reduction procedure for Courant algebroids and generalized complex structures generalizes both symplectic reduction and holomorphic reduction of complex manifolds.

Subobjects in this category are generalized complex branes. We will see how they mediate between Lagrangian submanifolds with a flat bundle and complex submanifolds with a holomorphic bundle. The deformation theory of generalized complex structures extends the deformation theory of complex and symplectic structures. In this context a Kähler structure can be generalized to recover bimeromorphic geometry discovered by Gates, Hull and Roček. Interesting results and applications include among other topics mirror symmetry and (2,2) supersymmetric sigma models. We will see examples of generalized Kähler structures on CP^2 and on instanton moduli spaces.

Prior knowledge: smooth manifolds, complex geometry

The aim of this course is to give an introduction to A¹-homotopy theory following Morel and Voevodsky. In particular, we will develop enough machinery to understand Morel’s computation of the homotopy groups of spheres in the so-called Milnor range. If time permits, we will also discuss some applications to vector bundles on smooth affine varieties.

Prior Knowledge: Basic knowledge of algebraic geometry (scheme theory) and algebraic topology.
### Electives: Applied Mathematics and Further Application-Oriented Fields

#### Selection: Numerical Analysis

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-4657-00L</td>
<td>Numerical Solution of Stochastic Ordinary Differential Equations</td>
<td>W</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>A. Stein</td>
</tr>
</tbody>
</table>

**Abstract**
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering.

**Objective**
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

**Content**
- Brownian motion and Lévy processes
- Stochastic integration and stochastic calculus
- Stochastic ordinary differential equations (SDEs)
- Numerical approximations of SDEs
- Stochastic simulation and Monte Carlo methods

**Lecture notes**
There will be English, typed lecture notes for registered participants in the course.

**Literature**

**Prerequisites / notice**
- Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.
- a) mandatory courses:
  - Elementary Probability, Probability Theory I.
- b) recommended courses:
  - Stochastic Processes.

**Start of lectures:** Wednesday September 21, 2022.

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<tr>
<th>Number</th>
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<th>Type</th>
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<tbody>
<tr>
<td>401-4785-00L</td>
<td>Mathematical and Computational Methods in Photonics</td>
<td>W</td>
<td>8 credits</td>
<td>4G</td>
<td>H. Ammari</td>
</tr>
</tbody>
</table>

**Abstract**
The aim of this course is to review new and fundamental mathematical tools, computational approaches, and inversion and optimal design methods used to address challenging problems in nanophotonics. The emphasis will be on analyzing plasmon resonant nanoparticles, super-focusing & super-resolution of electromagnetic waves, photonic crystals, electromagnetic cloaking, metamaterials, and metasurfaces.

**Start of lectures:** Does not take place this semester.
The field of photonics encompasses the fundamental science of light propagation and interactions in complex structures, and its technological applications. The recent advances in nanoscience present great challenges for the applied and computational mathematics community. In nanophotonics, the aim is to control, manipulate, reshape, guide, and focus electromagnetic waves at nanometer length scales, beyond the resolution limit. In particular, one wants to break the resolution limit by reducing the focal spot and confine light to length scales that are significantly smaller than half the wavelength.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare. Light-based technologies can be used effectively for the very early detection of diseases, with non-invasive imaging techniques or point-of-care applications. They are also instrumental in the analysis of processes at the molecular level, giving a greater understanding of the origin of diseases, and hence allowing prevention along with new treatments. Photonic technologies also play a major role in addressing the needs of our ageing society: from pace-makers to synthetic bones, and from endoscopes to the micro-cameras used in in-vivo processes. Furthermore, photonics are also used in advanced lighting technology, and in improving energy efficiency and quality. By using photonic media to control waves across a wide band of wavelengths, we have an unprecedented ability to fabricate new materials with specific microstructures.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonic crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-mathematics in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena. An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

### Selection: Probability Theory, Statistics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3628-14L</td>
<td>Bayesian Statistics</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Does not take place this semester.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Topics that we will discuss are:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>A script will be available in English.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Prerequisites / notice: Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

Additional references will be given in the course.

### Objective

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

### Lecture notes


The exercises will be done using the software R. A script will be available in English.

### Prerequisites / notice

Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Additional references will be given in the course.

### Literature


The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

### Course content

1. Theory: in this course, we will discuss the trade-off between accuracy and stability of classification algorithms and study the state-of-the-art for robust image classification, adversarial attacks and adversarial training.

2. Practice: students will train and attack deep neural networks themselves, to get a hands-on experience.

### Additional references

Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis. The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Prerequisites / notice
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

401-3627-00L High-Dimensional Statistics W 4 credits 2V P. L. Bühlmann
Does not take place this semester.

Abstract
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Objective
Knowledge of methods and basic theory for high-dimensional statistical inference

Content
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

Literature

Prerequisites / notice
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

401-4623-00L Time Series Analysis W 4 credits 2G N. Meinshausen

Abstract
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARIMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting

Literature
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice
Basic knowledge in probability and statistics

401-3612-00L Stochastic Simulation W 5 credits 2V+1U F. Sigrist

Abstract
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.


A script will be available in English.


Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

### Topics discussed will include:
- Discrete and continuous Gaussian Free Field
- Local sets.
- Relation to loop-soups.
- Uniform spanning trees.

#### 401-4597-67L Random Walks on Transitive Graphs

**Abstract**
In this course, we will present modern topics at the interface between probability and geometric group theory. We will be mainly focused on the random walk, and discuss its behavior depending on the geometric properties of the underlying graph.

**Prerequisites / notice**
- Probability Theory.
- Basic properties of Markov Chains.
- No prerequisite on group theory, all the background will be introduced in class.

#### Selection: Financial and Insurance Mathematics

In the Master's programmes in Mathematics resp. Applied Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course, but only if 401-3888-00L Introduction to Mathematical Finance isn't recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3925-00L</td>
<td>Non-Life Insurance: Mathematics and Statistics</td>
<td>W</td>
<td>8 credits</td>
<td>4V+1U</td>
<td>M. V. Wüthrich</td>
</tr>
</tbody>
</table>

The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

**Content**
The following topics are treated:
- Collective Risk Modeling
- Individual Claim Size Modeling
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tariffication
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

**Lecture notes**
M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
http://ssrn.com/abstract=2319328

**Prerequisites / notice**
The exams ONLY take place during the official ETH examination period (and they will be in person at ETH, this also applies to exchange/mobility students).

This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

**Taught competencies**

- Subject-specific Competencies: knowledge of probability theory, statistics and applied stochastic processes.
- assessed
- assessed
- assessed
- not assessed
- not assessed

| 401-3922-00L | Life Insurance Mathematics | W    | 4 credits | 2V | M. Koller |

The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

| 401-3928-00L | Reinsurance Analytics | W    | 4 credits | 2V |

Does not take place this semester.
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds

An excerpt of last year's lecture notes is available here: https://sites.google.com/site/philipparbenz/reinsuranceanalytics

Basic knowledge in statistics, probability theory, and actuarial techniques

Abstract

In life insurance, it is essential to have adequate mortality tables, be it for reserving or pricing purposes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities

Objective

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds

Content

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
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- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds

Lecture notes

Slides and lecture notes will be made available.

Prerequisites / notice

Basic knowledge in statistics, probability theory, and actuarial techniques

401-3927-00L

Mathematical Modelling in Life Insurance

Does not take place this semester.

Abstract

In life insurance, it is essential to have adequate mortality tables, be it for reserving or pricing purposes. The course provides the tools necessary to create mortality tables from scratch. Additionally, we study various guarantees embedded in life insurance products and learn to price them with the help of stochastic models.

Objective

The course's objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn to price embedded options in life insurance. Aside of the mere application of specific models, they should develop an intuition for the various drivers of the value of these options.

Content

Following main topics are covered:

1. Guarantees and options embedded in life insurance products.
   - Stochastic valuation of participating contracts
   - Stochastic valuation of Unit Linked contracts
2. Mortality Tables:
   - Determining raw mortality rates
   - Smoothing techniques: Whittaker-Henderson, smoothing splines,...
   - Trends in mortality rates
   - Stochastic mortality model due to Lee and Carter
   - Neural Network extension of the Lee-Carter model
   - Integration of safety margins

Lecture notes

Lectures notes and slides will be provided
### Courses and Semesters

**401-3931-00L Responsible Machine Learning with Insurance**

**Applications**

This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

**Objective**

The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

**Content**

- Overview of supervised machine learning (statistical learning theory, GLMs, tree-based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

**Prerequisites**

This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

**Literature**

No specific book is used for the course. Relevant literature will be given in the course.

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### Selection: Mathematical Physics, Theoretical Physics

**Number**

<table>
<thead>
<tr>
<th>402-0843-00L</th>
<th>Quantum Field Theory I</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>W</td>
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<tr>
<td><strong>ECTS</strong></td>
<td>10 credits</td>
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<tr>
<td><strong>Hours</strong></td>
<td>4V+2U</td>
</tr>
<tr>
<td><strong>Lecturers</strong></td>
<td>R. Renner</td>
</tr>
</tbody>
</table>

**Abstract**

This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity. Topics include:

- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

**Objective**

The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore, it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

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**Number**

<table>
<thead>
<tr>
<th>402-0861-00L</th>
<th>Statistical Physics</th>
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<tbody>
<tr>
<td><strong>Type</strong></td>
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<td><strong>ECTS</strong></td>
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<tr>
<td><strong>Hours</strong></td>
<td>4V+2U</td>
</tr>
<tr>
<td><strong>Lecturers</strong></td>
<td>E. Demler</td>
</tr>
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</table>

**Abstract**

This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena, and superfluidity.

**Objective**

This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.

**Content**

Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.

Classical statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.

Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons.

Identical quantum particles: many body wave functions, second quantization formalism, equation of motion, correlation functions, selected applications, e.g., Bose-Einstein condensate and coherent state, phonons in elastic media and melting.

One-dimensional interacting systems.

Phase transitions: mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls' arguments on long-range order.


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**Data:** 18.08.2022 12:39  |  **Autumn Semester 2022**  |  **Page 1697 of 2345**
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.

Objectives
- Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).
- Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

Literature
- Suggested textbooks:
  - C. Misner, K. Thorne and J. Wheeler: Gravitation
  - S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
  - R. Wald - General Relativity
  - S. Weinberg - Gravitation and Cosmology

Introduction to String Theory

This course provides a gentle introduction to string theory, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Objective
Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Content
- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- D-branes, T-duality
- supergravity as a low-energy effective theory, strings on curved backgrounds
- two-dimensional field theories (classical/quantum, conformal/non-conformal)

Literature
- D. Lust, S. Theisen, Lectures on String Theory, Lecture Notes in Physics, Springer (1989);
- M.B. Green, J.H. Schwarz, E. Witten, Superstring Theory I, CUP (1987);
- B. Zwiebach, A First Course in String Theory, CUP (2004);

Prerequisites / notice
Recommended: Quantum Field Theory I (in parallel)

Selection: Mathematical Discrete Mathematics

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
401-3055-64L | Algebraic Methods in Combinatorics | W | 6 credits | 2V+1U | B. Sudakov

Abstract
Combiningatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content
Combiningatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvectors of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem.
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at [https://moodle-app2.let.ethz.ch/course/view.php?id=15757](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)

Lecture notes
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice
Students are expected to have a mathematical background and should be able to write rigorous proofs.

Selection: Theoretical Computer Science, Discrete Mathematics

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
252-1425-00L | Geometry: Combinatorics and Algorithms | W | 8 credits | 3V+2U+2A | B. Gärtner, E. Welzl, M. Hoffmann

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice
Recommended: Quantum Field Theory I (in parallel)
Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

**Objective**
The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

**Content**
Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in R^d, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

**Lecture notes**
Yes.

**Literature**

**Prerequisites / notice**
Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

### 252-0417-00L Randomized Algorithms and Probabilistic Methods

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>2014</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10</td>
<td></td>
<td>A. Steger</td>
</tr>
</tbody>
</table>

**Abstract**
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

**Objective**
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**
Randomized algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Lecture notes**
Yes.

**Literature**

### Selection: Further Realms and Some UZH Courses

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>401-4944-20L</td>
<td>Mathematics of Data Science</td>
<td>W</td>
<td>8</td>
<td>4G</td>
<td>A. Bandeira</td>
</tr>
</tbody>
</table>

**Abstract**
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

**Objective**
Introduction to various mathematical aspects of Data Science.

**Content**
These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

**Lecture notes**

**Prerequisites / notice**
The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0423-00L</td>
<td>Neural Network Theory</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Bölcskei</td>
</tr>
</tbody>
</table>

**Abstract**
Does not take place this semester.

**Objective**
After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

**Content**
1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning.

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

By the end of the semester students should be able to:

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression", "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH).
After the course students should have learned topics of spectral theory for unbounded operators and the description of simple models of one-particle quantum systems.

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the mathematical aspects of quantum mechanics.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td></td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**401-8815-72L Mathematical Aspects of Quantum Mechanics**

*(University of Zurich)*

- **Title**: Mathematical Aspects of Quantum Mechanics
- **Type**: W 6 credits 4V
- **Objective**: After the course students should have learned topics of spectral theory for unbounded operators and the description of simple models of one-particle quantum systems.
- **Content**: The course aims at presenting the basic theory of Quantum Mechanics from the mathematical point of view. No prior knowledge of Quantum Mechanics is required, and the language and tools necessary to develop the theory will be explicitly introduced.
- **Abstract**: The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes.
- **Prerequisites / notice**: The prerequisites are real analysis, and linear algebra. Basic knowledge of classical physics, operator theory on Hilbert spaces, and the Fourier transform are helpful but not required.
- **Literature**: 
  - Lecture note written by Benjamin Schlein for the course MAT631 Mathematical Aspects of Quantum Mechanics for the Spring Semester 2018
  - Schmüdgen – Unbounded Self-adjoint Operators on Hilbert Space
  - Teta - A Mathematical Primer on Quantum Mechanics

**401-8877-72L Introduction to Batalin-Vilkovisky Formalism**

*(University of Zurich)*

- **Title**: Introduction to Batalin-Vilkovisky Formalism
- **Type**: W 3 credits 2V
- **Objective**: Understanding the main problems and concepts associated with the path integral formulation of Quantum Field Theory.
- **Content**: This will be followed by the analysis of simple models of one-particle systems such as the free particle, the harmonic oscillator, and the hydrogen atom. Further topics as conservation laws and the angular momentum operators will also be discussed. If time permits, we will also touch more advanced topics, as for example the theory of general Schrödinger operators and the semiclassical approximation.
- **Abstract**: This class will be an introduction to the perturbative path integral for gauge theories in Batalin-Vilkovisky formalism and the associated mathematical concepts, following P. Mnëv’s lecture notes (available on ArXiv)
- **Prerequisites / notice**: Prior knowledge: basics of analysis, linear algebra and (algebraic) topology

**Electives (Direction Applied Mathematics MSc Only)**

Electives from applied mathematics and further application-oriented fields that are only eligible for credits for the Master's degree in Applied Mathematics.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0532-00L</td>
<td>Nonlinear Dynamics and Chaos I</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>G. Haller</td>
</tr>
</tbody>
</table>

**Abstract**: Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

**Objective**: This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

**Content**

1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

**Lecture notes**: The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

**Prerequisites / notice**

- Prerequisites: Analysis, linear algebra and a basic course in differential equations
- Exam: two-hour written exam in English
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

**Application Area**
Atmospheric Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4 credits</td>
<td>2+1U</td>
<td>H. Wernli, L. Papritz</td>
</tr>
</tbody>
</table>

Abstract
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Objective
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

Content
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes
Dynamics of large-scale atmospheric flow

Prerequisites / notice
Physics I, II, Environmental Fluid Dynamics

Biology

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0017-00L</td>
<td>Computational Biology</td>
<td>W</td>
<td>6 credits</td>
<td>3G+2A</td>
<td>T. Vaughan, C. Magnus, T. Stadler</td>
</tr>
</tbody>
</table>

Abstract
The aim of the course is to provide an introductory overview of computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic, and systems analysis (complexity reduction, stability, identification).

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

* epidemiology
* pathogen evolution
* macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary conceptual tools to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylopythons, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

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<tr>
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<th>ECTS</th>
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</tr>
</thead>
<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
</tbody>
</table>

Abstract

Objective
The aim of this course is to provide an introductory overview of computational methods for the modeling, simulation and analysis of biological networks.

Content
Biologist has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes
http://www.csb.ethz.ch/education/lectures.html

Literature
Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

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The learning objectives of the course are:

For pension insurance and other forms of social insurance, investment returns are an important source of funding. In order to earn these returns, substantial financial risks must be taken, and these risks represent an important threat to financial stability, in the long term and in the short term.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.

363-0537-00L Resource and Environmental Economics W 3 credits 2G L. Bretschger

Abstract Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

Objective A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource economics and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.


363-0503-00L Principles of Microeconomics W 3 credits 2G M. Filippini

Abstract This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Objective The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

1. Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
N. Gregory Mankiw and Mark P. Taylor (2020), "Economics", 5th edition, South-Western Cengage Learning. The book can also be used for the course 'Principles of Microeconomics' (Sturm)

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>not assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Project Management</td>
<td>not assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptable and Flexibility</td>
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<tr>
<td>Creative Thinking</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature
The set-up of the course will closely follow the book of N. Gregory Mankiw and Mark P. Taylor (2020), Economics, Cengage Learning, Fifth Edition. This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<td></td>
<td>Negotiation</td>
<td>not assessed</td>
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</tbody>
</table>

| Personal Competencies         | Adaptability and Flexibility | not assessed |
|                              | Creative Thinking | not assessed |
|                              | Critical Thinking | assessed |
|                              | Integrity and Work Ethics | not assessed |
|                              | Self-awareness and Self-reflection | not assessed |

363-1021-00L Monetary Policy W 3 credits 2V J.-E. Sturm, A. Rathke

Abstract

The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real-world issues.

Objective

This lecture will introduce the fundamentals of monetary economics and explain the working and impact of monetary policy. The main aim of this course is to describe and analyze the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, the differences between monetary policy rules and discretionary policy, as well as in institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.

Content

For the functioning of today’s economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls either the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today’s major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

Lecture notes

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17629) contains announcements, course information and lecture slides.

Literature

The course will be based on chapters of:


Prerequisites / notice

Basic knowledge in international economics and a good background in macroeconomics.

363-1017-00L Risk and Insurance Economics W 3 credits 2G H. Schernberg

Abstract

The course covers the economics of risk and insurance, in particular the following topics will be discussed:

2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective

The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people’s risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model’s underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don’t fit with the basic models of microeconomic theory. For example, we’ll explore how behavioural economics can be leveraged by the insurance industry.

Main literature:

- Handbook of the Economics of Risk and Uncertainty. Volume1;

Further readings:


References will be given on a topic-by-topic basis during the course.

Literature

**Main literature:**

- Handbook of the Economics of Risk and Uncertainty, Volume1;

**Further readings:**


References will be given on a topic-by-topic basis during the course.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
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<tr>
<td>as assessed</td>
<td>Problem-solving</td>
<td>as assessed</td>
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</tbody>
</table>

**Finance**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-8905-00L</td>
<td>Financial Engineering (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>University lecturers</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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<tr>
<td></td>
<td>UZH Module Code: MFOEC200</td>
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<td></td>
<td>Mind the enrolment deadlines at UZH:</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>This lecture is intended for students who would like to learn more on equity derivatives modelling and pricing.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Quantitative models for European option pricing (including stochastic volatility and jump models), volatility and variance derivatives, American and exotic options.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>After introducing fundamental concepts of mathematical finance including no-arbitrage, portfolio replication and risk-neutral measure, we will present the main models that can be used for pricing and hedging European options e.g. Black-Scholes model, stochastic and jump-diffusion models, and highlight their assumptions and limitations. We will cover several types of derivatives such as European and American options, Barrier options and Variance Swaps. Basic knowledge in probability theory and stochastic calculus is required. Besides attending class, we strongly encourage students to stay informed on financial matters, especially by reading daily financial newspapers such as the Financial Times or the Wall Street Journal.</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<tr>
<td></td>
<td>Script.</td>
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<tr>
<td></td>
<td>Basic knowledge of probability theory and stochastic calculus. Asset Pricing.</td>
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<tr>
<td>401-8913-00L</td>
<td>Advanced Corporate Finance I (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td>Mind the enrolment deadlines at UZH:</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course develops and refines tools for evaluating investments (capital budgeting), capital structure, and corporate securities. The course seeks to deepen students' understanding of the link between corporate finance theory and practice.</td>
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</table>
This course develops and refines tools for evaluating investments (capital budgeting), capital structure, and corporate securities. With respect to capital structure, we start with the famous Miller and Modigliani irrelevance proposition and then move on to study the effects of taxes, bankruptcy costs, information asymmetries between firms and the capital markets, and agency costs. In this context, we will also study how leverage affects some central financial ratios that are often used in practice to assess firms and their stock. Other topics include corporate cash holdings, the use and pricing of convertible bonds, and risk management. The latter two topics involve option pricing. With respect to capital budgeting, the course pays special attention to tax effects in valuation, including in the estimation of the cost of capital. We will also study payout policy (dividends and share repurchases). The course seeks to deepen students' understanding of the link between corporate finance theory and practice. Various cases will be assigned to help reach this objective.

### Topics covered

1. Capital structure: Perfect markets and irrelevance
2. Risk, leverage, taxes, and the cost of capital
3. Leverage and financial ratios
4. Payout policy: Dividends and share repurchases
5. Capital structure: Taxes and bankruptcy costs
6. Capital structure: Information asymmetries, agency costs, cash holdings
7. Valuation: DCF, adjusted present value and WACC
8. Valuation using options
9. The use and pricing of convertible bonds
10. Corporate risk management

### Prerequisites

This course replaces "Advanced Corporate Finance I" (MOEC0288), which will be discontinued from HS16.

#### Image Processing and Computer Vision

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>E. Konukoglu, F. Yu</td>
</tr>
</tbody>
</table>

**Abstract**


**Objective**

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content**

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Lecture notes**

Course material, Script, computer demonstrations, exercises and problem solutions

**Prerequisites**

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

#### Information and Communication Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0150-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

**Abstract**

Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

**Objective**

Students master the basic mathematical concepts and algorithms of estimation and machine learning.

**Content**

Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more.

**Lecture notes**

Lecture notes will be handed out as the course progresses.

**Prerequisites**

Basic concepts of mathematical analysis and linear algebra theory

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

**Abstract**

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

**Objective**

The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust “inversion” of a linear filter.
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

### Machine Learning

The list is not yet complete.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-3210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
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<td></td>
<td>The fundamentals of Information Theory including Shannon's source coding and channel coding theorems</td>
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<tr>
<td></td>
<td>Content</td>
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<td></td>
<td>The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>T.M. Cover and J. Thomas, Elements of Information Theory (second edition)</td>
</tr>
</tbody>
</table>

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**Number of participants limited to 250.**

**Number of participants limited to 320.**

**Number of participants limited to 400.**

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**Prerequisites / notice**

- Solid basic knowledge in statistics, algorithms and programming.
- The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

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**Prerequisites / notice**

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
- Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/
- Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/
- Introduction to Machine Learning
  https://las.inf.ethz.ch/teaching/introml-S19
- Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/
- Computational Statistics
  https://stat.ethz.ch/lectures/s19/comp-stats.php
- Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-118

---

**Objective**

- The participation in the course is subject to the following condition:
  - Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/s19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-118

- The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

---

**Content**

1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum,
   - decision and interpolation, digital filter design,
   - stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   - probability, random variables, discrete-time stochastic processes;
   - detection and estimation: MAP, ML, Bayesian MMSE, LMMSE;
   - Wiener filter, LMS adaptive filter, Viterbi algorithm.

---

**Literature**

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)
Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

263-5255-00L Foundations of Reinforcement Learning

W 5 credits 2V+2A N. He

The course will be offered again in FS23.

Abstract
Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control.

Objective
This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to:
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content
Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL. Policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also address advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes
Lecture notes will be posted on Moodle.

Literature
Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepevsarí.

Prerequisites / notice
Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

Material Modelling and Simulation

Number Title Type ECTS Hours Lecturers
327-1201-00L Transport Phenomena I W 5 credits 4G J. Vermant

Abstract
Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

Objective
The teaching goals of this course are on five different levels:
(1) Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling. …
(2) Ability to use the fundamental concepts in applications
(3) Insight into the role of boundary conditions (mainly part 2)
(4) Knowledge of a number of applications.
(5) Flavor of numerical techniques: finite elements and finite differences.

Content
Part 1 Approach to Transport Phenomena
Equilibrium Thermodynamics
Balance Equations
Forces and Fluxes
Applications
1. Measuring Transport Coefficients
2. Fluid mechanics
3. combined heat and flow

Lecture notes

Literature

Quantum Chemistry

Number Title Type ECTS Hours Lecturers
529-0003-01L Advanced Quantum Chemistry W 6 credits 3G M. Reiher, A. Baiardi

Abstract
Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer.
Examples are:
* Operators derived from principles of relativistic quantum mechanics
* Relativistic effects + methods of relativistic quantum chemistry
* Open-shell molecules + spin-density functional theory
* New electron-correlation theories

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1710 of 2345
Objective

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

Content

1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein’s special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group
9) Quantum chemistry without the Born-Oppenheimer approximation

Lecture notes

A set of detailed lecture notes will be provided, which will cover the whole course.

Literature

2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992
http://pubs.rsc.org/en/Content/ArticleLanding/2011/CP/c1cp01863d
http://pra.aps.org/abstract/PRA/v83/i5/e052512
Note also the standard textbooks:
A) A. Szabo, N.S. Ostlund. Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Prerequisites / notice

Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

Simulation of Semiconductor Devices

"Simulation of Semiconductor Devices" is no longer offered as an application area.

Systems Design

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0541-00L</td>
<td>Systems Dynamics and Complexity</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>F. Schweitzer</td>
</tr>
</tbody>
</table>

Abstract

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

Objective

A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics
Lecture notes and slides are available online and will be distributed if desired. Lecture notes available in English.

This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism are included.

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see "Prerequisites").

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

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**Theoretical Physics**

In the Master's programme in Applied Mathematics 402-0205-00L Quantum Mechanics I is eligible as a course unit in the application area Theoretical Physics, but only if 402-0224-00L Theoretical Physics wasn't or isn't recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
402-0809-00L | Introduction to Computational Physics | W | 8 credits | 2V+2U | A. Adelmann

Objective

Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Content

Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Lecture notes

Lecture notes and slides are available online and will be distributed if desired.

Literature

Literature recommendations and references are included in the lecture notes.

Prerequisites / notice

Lecture and exercise lessons in english, exams in German or in English

---

402-2203-01L | Classical Mechanics | W | 7 credits | 4V+2U | M. Gaberdiel

Abstract

A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

Objective

Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

---

402-0861-00L | Statistical Physics | W | 10 credits | 4V+2U | E. Demler

Abstract

This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.

Objective

This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.

Content


Lecture notes

Lecture notes available in English.

Literature

No specific book is used for the course. Relevant literature will be given in the course.

---

402-0843-00L | Quantum Field Theory I | W | 10 credits | 4V+2U | R. Renner

Special Students UZH must book the module PHY551 directly at UZH.
### Abstract

This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity.

Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

### Objective

The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore, it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

### Lecture notes

Will be provided as the course progresses

### Electives Theoretical Physics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0417-00L</td>
<td>Transport Planning Methods</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>K. W. Axhausen</td>
</tr>
</tbody>
</table>

### Literature

- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

### Content

The course provides the necessary knowledge to develop models supporting the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis.

- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve/answer planning problems
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis. Interim lab sessions take place regularly to guide and support students with the applied part of the course.

Moodle platform (enrollment needed)
The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).

Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, linearity might be too simplistic to capture the actual relationship between some response and given covariates. Also, there are many real data problems where linearity is plausible but the actual pairing between the observed covariates and responses is completely lost or at partially. In this seminar, we review some of the non-classical regression models and the statistical properties of the estimation methods considered by well-known statisticians and machine learners. This will encompass:

1. Monotone regression
2. Single index model
3. Unlinked regression

The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

In the following is the tentative material that will be read and studied by each pair of students (all the items listed below are available through the ETH electronic library or arXiv).

8. "Linear regression with shuffled data: statistical and computation limits of permutation recovery" by A. Pananjady, M. Wainwright and T. A. Courtade, 2018, IEEE transactions in Information Theory, Volume 64, 3286-3300
9. "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS
11. "Uncoupled isotonic regression via minimum Wasserstein deconvolution" by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27

In this seminar, we review some of the non-standard regression models and the statistical properties of estimation methods in such models. The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).

The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.
401-3760-72L  Topics in Fluid Dynamics  
Number of participants limited to 12.

401-3940-72L  Student Seminar in Mathematics and Data: Differential Privacy  
Number of participants limited to 12.

401-3050-72L  Student Seminar in Combinatorics  
Number of participants limited to 12.

Abstract  
The seminar will consist of student presentations and will cover a variety of topics in modern-day combinatorics. The seminar is aimed at third year bachelor students or master students with a background in combinatorics (e.g. the Graph Theory course).

Objective  
The seminar’s aim is to acquaint students with interesting results, proofs and techniques in combinatorics and graph theory, and to give them the opportunity to work with advanced research papers and practice their presentation skills.

Semester Papers  
There are several course units “Semester Paper” that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3750-01L</td>
<td>Semester Paper (No. 1)</td>
<td>W</td>
<td>8</td>
<td>11A</td>
<td>Supervisors</td>
</tr>
<tr>
<td></td>
<td>Successful participation in the course unit 401-2000-00L</td>
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<tr>
<td></td>
<td>Scientific Works in Mathematics is required.</td>
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<td></td>
<td>For more information, see <a href="http://www.math.ethz.ch/intranet/students/study-administration/theses.html">www.math.ethz.ch/intranet/students/study-administration/theses.html</a></td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Semester Papers help to deepen the students' knowledge of a specific subject area. Students are offered a selection of topics. These papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing.</td>
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<td>Prerequisites / notice</td>
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<tr>
<td></td>
<td>There are several course units “Semester Paper” that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.</td>
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</table>

| 401-3750-02L | Semester Paper (No. 2) | W    | 8    | 11A   | Supervisors         |
|          | Successful participation in the course unit 401-2000-00L |      |      |       |                     |
|          | Scientific Works in Mathematics is required. |      |      |       |                     |
|          | For more information, see www.math.ethz.ch/intranet/students/study-administration/theses.html |      |      |       |                     |
|          | Abstract                         |      |      |       |                     |
|          | Semester Papers help to deepen the students' knowledge of a specific subject area. Students are offered a selection of topics. These papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing. |      |      |       |                     |
|          | Prerequisites / notice           |      |      |       |                     |
|          | There are several course units “Semester Paper” that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again. |      |      |       |                     |

| 401-3750-03L | Semester Paper (No. 3) | W    | 8    | 11A   | Supervisors         |
|          | Successful participation in the course unit 401-2000-00L |      |      |       |                     |
|          | Scientific Works in Mathematics is required. |      |      |       |                     |
|          | For more information, see www.math.ethz.ch/intranet/students/study-administration/theses.html |      |      |       |                     |
|          | Abstract                         |      |      |       |                     |
|          | Semester Papers help to deepen the students' knowledge of a specific subject area. Students are offered a selection of topics. These papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing. |      |      |       |                     |
|          | Prerequisites / notice           |      |      |       |                     |
|          | There are several course units “Semester Paper” that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again. |      |      |       |                     |

Science in Perspective  
Two credits are needed from the “Science in Perspective” programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree. see https://ethz.ch/content/dam/ethz/common/docs/weisungssammlung/files-en/science-in-perspective.pdf (Eight credits must be acquired in this category: normally six during the Bachelor's degree programme, and two during the Master's degree programme. A maximum of three credits from language courses from the range of the Language Center of the University of Zurich and ETH Zurich may be recognised. In addition, only advanced courses (level B2 upwards) in the European languages English, French, Italian and Spanish are recognised. German language courses are recognised from level C2 upwards.)

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MATH

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis  

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Mathematics</td>
<td>O</td>
<td>0</td>
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<td>D. Possamai</td>
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<tr>
<td></td>
<td>Target audience: Third year Bachelor students; Master students who cannot document to have received an adequate training in working scientifically.</td>
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<tr>
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<td>Abstract</td>
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<tr>
<td></td>
<td>Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)</td>
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<td>Objective</td>
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<tr>
<td></td>
<td>Learn the basic standards of scientific works in mathematics.</td>
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<tr>
<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>- Types of mathematical works</td>
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<tr>
<td></td>
<td>- Publication standards in pure and applied mathematics</td>
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<td></td>
<td>- Data handling</td>
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<td>- Ethical issues</td>
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<td></td>
<td>- Citation guidelines</td>
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# Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0 credits</td>
<td>0</td>
<td>R. Abgrall, M. Iacobelli, A. Bandeira, A. Iozzi, S. Mishra, R. Pandharipande, University lecturers</td>
</tr>
<tr>
<td>401-5990-00L</td>
<td>Zurich Graduate Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>A. Iozzi, further speakers</td>
</tr>
<tr>
<td>401-4530-00L</td>
<td>Geometry Graduate Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>Speakers</td>
</tr>
<tr>
<td>401-5110-00L</td>
<td>Number Theory Seminar</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>Ö. Imamoglu, E. Kowalski, R. Pink, G. Wüstholz, S. Zerbes</td>
</tr>
<tr>
<td>401-5350-00L</td>
<td>Analysis Seminar</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>F. Da Lio, A. Figalli, N. Hungerbühler, M. Iacobelli, T. Ilmanen, L. Keller, T. Rivière, J. Serra, University lecturers</td>
</tr>
<tr>
<td>401-5370-00L</td>
<td>Ergodic Theory and Dynamical Systems</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>M. Akka Ginosar, M. Einsiedler, University lecturers</td>
</tr>
<tr>
<td>401-5530-00L</td>
<td>Geometry Seminar</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>M. Burger, M. Einsiedler, P. Feller, A. Iozzi, U. Lang</td>
</tr>
<tr>
<td>401-5580-00L</td>
<td>Symplectic Geometry Seminar</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>P. Biran, A. Cannas da Silva</td>
</tr>
<tr>
<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>A. Cattaneo, G. Felder, M. Gaberdiel, G. M. Graf, P. Hintz, T. H. Willwacher</td>
</tr>
<tr>
<td>401-5650-00L</td>
<td>Zurich Colloquium in Applied and Computational Mathematics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>R. Abgrall, R. Alaiifar, H. Ammari, R. Hiptmair, S. Mishra, S. Sauter</td>
</tr>
<tr>
<td>401-5600-00L</td>
<td>Seminar on Stochastic Processes</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>J. Bertoin, A. Nikeghbali, B. D. Schlein, V. Tassion, W. Werner</td>
</tr>
</tbody>
</table>

**Objective**

See how statistical methods are applied in practice.

**Content**

There will be about 5 talks on how statistical methods are applied in practice.
This is no lecture. There is no exam and no credit points will be awarded. The current program can be found on the web:
http://stat.ethz.ch/events/zukost
Course language is English or German and may depend on the speaker.

401-5680-00L Foundations of Data Science Seminar E- 0 credits P. L. Bühlmann, A. Bandeira, H. Bölcskei, S. van de Geer, F. Yang
Abstract Research colloquium

401-5660-00L DACO Seminar E- 0 credits 1K A. Bandeira, R. Weismantel, R. Zenklusen
Abstract Research colloquium

401-5910-00L Talks in Financial and Insurance Mathematics E- 0 credits 1K B. Acciaio, P. Cheridito, D. Possamai, M. Schweizer, J. Teichmann, M. V. Wüthrich
Abstract Research colloquium
Content Regular research talks on various topics in mathematical finance and actuarial mathematics

401-5960-00L Colloquium on Mathematics, Computer Science, and Education E- 0 credits N. Hungerbühler, M. Akveld, D. Grawehr Morath, J. Hromkovic, P. Spindler
Abstract Didactics colloquium

402-0101-00L The Zurich Physics Colloquium E- 0 credits 1K S. Huber, A. Refregier, University lecturers
Abstract Research colloquium

402-0800-00L The Zurich Theoretical Physics Colloquium E- 0 credits 1K J. Renes, University lecturers
Abstract The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.

251-0100-00L Computer Science Colloquium E- 0 credits 2K Lecturers
Abstract Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.
Objective Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department's professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.
Content Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>406-2004-AAL</td>
<td>Algebra II</td>
<td>E-</td>
<td>5</td>
<td>11R</td>
<td>L. Halbeisen</td>
</tr>
<tr>
<td>Abstract</td>
<td>Galois theory and related topics.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The precise content changes with the examiner.</td>
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<tr>
<td>Content</td>
<td>The main topic is Galois Theory. Starting point is the problem of solvability of algebraic equations by radicals, Galois theory solves this problem by making a connection between field extensions and group theory. Galois theory will enable us to prove the theorem of Abel-Ruffini, that there are polynomials of degree 5 that are not solvable by radicals, as well as Galois' theorem characterizing those polynomials which are solvable by radicals.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Galois Theory is the topic treated in Chapter A5. Algebra I, in Rotman's book this corresponds to the topics treated in the Chapters A3 and A4.</td>
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</tbody>
</table>

| 406-2005-AAL | Algebra I and II                                 | E-   | 12   | 26R   | L. Halbeisen |
| Abstract    | Introduction and development of some basic algebraic structures - groups, rings, fields including Galois theory, representations of finite groups, algebras. The precise content changes with the examiner. Candidates must therefore contact the examiner in person before studying the material. | | | |

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1717 of 2345
Content

Basic notions and examples of groups:
Subgroups, Quotient groups and Homomorphisms,
Group actions and applications

Basic notions and examples of rings:
Ring Homomorphisms,
ideals, and quotient rings, rings of fractions
Euclidean domains, Principal ideal domains, Unique factorization domains

Basic notions and examples of fields:
Field extensions, Algebraic extensions, Classical straight edge and compass constructions

Fundamentals of Galois theory
Representation theory of finite groups and algebras

Literature
Joseph J. Rotman, "Advanced Modern Algebra" third edition, part 1,
Graduate Studies in Mathematics, Volume 165
American Mathematical Society

406-2303-AAL Complex Analysis
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, conformal mappings, Riemann mapping theorem.

Literature

B. Palka: "An introduction to complex function theory."

R. Remmert: Theory of Complex Functions. Springer Verlag

E. Hille: Analytic Function Theory. AMS Chelsea Publication

406-2284-AAL Measure and Integration
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the abstract measure theory and integration, including the following topics: Lebesgue measure and Lebesgue integral, Lp-spaces, convergence theorems, differentiation of measures, product measures (Fubini’s theorem), abstract measures, Radon-Nikodym theorem, probabilistic language.

Objective
Basic acquaintance with the theory of measure and integration, in particular, Lebesgue’s measure and integral.

Literature
1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy "Measure theory and fine properties of functions"
3. Walter Rudin "Real and complex analysis"
4. R. Bartle The elements of Integration and Lebesgue Measure

406-2554-AAL Topology
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Topological spaces, continuous maps, connectedness, compactness, metric spaces, quotient spaces, homotopy, fundamental group and covering spaces, van Kampen Theorem.

Literature
James Munkres: Topology

Prerequisites / notice
The precise content changes with the examiner. Candidates must therefore contact the examiner in person before studying the material.

406-2604-AAL Probability and Statistics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to probability and statistics with many examples, based on chapters from the books "Probability and Random Processes" by G. Grimmett and D. Stirzaker and "Mathematical Statistics and Data Analysis" by J. Rice.

Objective
The goal of this course is to provide an introduction to the basic ideas and concepts from probability theory and mathematical statistics. In addition to a mathematically rigorous treatment, also an intuitive understanding and familiarity with the ideas behind the definitions are emphasized. Measure theory is not used systematically, but it should become clear why and where measure theory is needed.

Content
Probability:
Chapters 1-5 (Probabilities and events, Discrete and continuous random variables, Generating functions) and Sections 7.1-7.5 (Convergence of random variables) from the book "Probability and Random Processes". Most of this material is also covered in Chap. 1-5 of "Mathematical Statistics and Data Analysis", on a slightly easier level.

Statistics:
Sections 8.1 - 8.5 (Estimation of parameters), 9.1 - 9.4 (Testing Hypotheses), 11.1 - 11.3 (Comparing two samples) from "Mathematical Statistics and Data Analysis".
### Mathematics Master - Key for Type

<table>
<thead>
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<tr>
<td>O</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
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### Key for Hours

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<tr>
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<tr>
<td>G</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Micro- and Nanosystems Master

Core Courses

Devices and Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>T. Jang</td>
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</table>

**Abstract**
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

**Objective**
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

**Content**
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

**Lecture notes**
Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature**

Energy Conversion and Quantum Phenomena

<table>
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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>151-0913-00L</td>
<td>Introduction to Photonics</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>R. Quidant, J. Ortega Arroyo</td>
</tr>
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**Abstract**
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

**Objective**
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics I, Physics II

402-0468-15L Nanomaterials for Photonics W 6 credits 2V+1U R. Grange

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.
Content

1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modeling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

Semiconductor Nanostructures
W+ 6 credits 2V+1U T. M. Ihn

402-0595-00L

Abstract
The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

Objective
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots
Analytical Competencies

2V+1U assessed

Concepts and Theories

Title

A. E. Ehret

Acoustics in Fluid Media: From Robotics to Additive Manufacturing

In addition to the lecture notes, the following supplementary books can be recommended:


Prerequisites / notice

The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitioned students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Media and Digital Technologies assessed

Problem-solving not assessed

Method-specific Competencies

Social Competencies

Communication not assessed

Self-presentation and Social Influence assessed

Sensitivity to Diversity not assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-direction and Self-management not assessed

Material, Surfaces and Properties

Number | Title | Type | ECTS | Hours | Lecturers

151-0509-00L | Acoustics in Fluid Media: From Robotics to Additive Manufacturing | W | 4 credits | 3G | D. Ahmed

Abstract

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices

Literature


Prerequisites / notice

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions ( both compulsory) and hand in homework.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Decision-making not assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Method-specific Competencies

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-direction and Self-management assessed

Continuum Mechanics I

W+ 4 credits 2V+1U A. E. Ehret

Abstract

The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective

Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.
After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most


The course objectives are best met primarily through the individual student projects which may involve experiments, simulations or critical & quantitative reviews of the literature. Projects are conducted individually under the close supervision of MSc, PhD or post-doctoral students. Therein, a 2-page proposal is submitted within the first two semester weeks addressing explicitly, at least, 10 well-selected research articles and thoughtful meetings with the project supervisor. The proposal address 3 basic questions: a) how important is the project; b) what has been done already in that field and c) what will be done by the student. Detailed feedback on each proposal is given by the supervisor, assistant and professor two weeks later. Towards the end of the semester, a 10-minute oral presentation is given by the student followed by 10 minutes Q&A. A 10-page final report is submitted by noon of the last day of the semester. The project supervisor will provide guidance throughout the course. Lectures include some of the following:

- Overview & Project Presentation
- Particle Size Distribution
- Particle Diffusion
- Coagulation
- Agglomeration & Coalescence
- Particle Growth by Condensation
- Control of particle size & structure during gas-phase synthesis
- Multi-scale design of aerosol synthesis of particles
- Particle Characterization
- Aerosol manufacture of nanoparticles
- Forces acting on Single Particles in a Flow Field
- Fixed and Fluidized Beds
- Separations of Solid-Liquid & Solid-Gas systems
- Emulsions/droplet formation/microfluidics
- Gas Sensors
- Coaching for proposal & report writing as well as oral presentations


Prerequisites / notice

FluidMechanik I, Thermodynamik I & II & "clean" 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As projects pull their weight will be required. Having seen "Chasing Mavericks" (2012) by Apted & Henson, "Unbroken" (2014) by Angelina Jolie and, in particular, “The Salt of the Earth” (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).

Surfaces, Interfaces and their Applications I

After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

Introduction to Surface Science
Physical Structure of Surfaces
Surface Forces (static and dynamic)
Adsorbates on Surfaces
Surface Thermodynamics and Kinetics
The Solid-Liquid Interface
Electron Spectroscopy
Vibrational Spectroscopy on Surfaces
Scanning Probe Microscopy
Introduction to Tribology
Introduction to Corrosion Science

Chemistry:
General undergraduate chemistry
including basic chemical kinetics and thermodynamics

Physics:
General undergraduate physics
including basic theory of diffraction and basic knowledge of crystal structures
Modelling and Simulation

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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>

Abstract
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Objective
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the students to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Literature
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

Prerequisites / notice
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

Laboratory Course

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-0620-00L</td>
<td>Embedded MEMS Lab</td>
<td>W+</td>
<td>5</td>
<td>3P</td>
<td>C. Hierold, M. Haluska</td>
</tr>
</tbody>
</table>

Abstract
Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and characterization steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access

Objective
Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

Content
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Lecture notes
A document containing theory, background and practical course content is distributed at the introductory lecture day of the course.

Literature
The document provides sufficient information for the participants to successfully participate in the course.
Prerequisites / notice

Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Kaomoutsakos, Nelso, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

Elective Core Courses

<table>
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<tr>
<th>Number</th>
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<tr>
<td>151-0409-00L</td>
<td>Multiphysics Modeling and Simulation</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>C. I. Roman</td>
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</table>

Abstract

This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

Objective

As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling.

Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

Content

- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

Lecture notes

Lecture handouts will be posted online.

Subject-specific Competencies

Concepts and Theories  
Techniques and Technologies  
Analytical Competencies  
Decision-making  
Media and Digital Technologies  
Problem-solving  
Project Management

Method-specific Competencies

Communication  
Cooperation and Teamwork  
Customer Orientation  
Leadership and Responsibility  
Self-presentation and Social Influence  
Sensitivity to Diversity  
Negotiation

Social Competencies

Adaptability and Flexibility  
Creative Thinking  
Critical Thinking  
Integrity and Work Ethics  
Self-awareness and Self-reflection  
Self-direction and Self-management

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

151-0525-00L

Dynamic Behavior of Materials

W  4 credits  2V+2U  D. Mohr, C. Roth, T. Tancogne-Dejean

Abstract

Lectures and computer labs concerned with the modeling of the deformation response and failure of engineering materials (metals, polymers and composites) subject to extreme loadings during manufacturing, crash, impact and blast events.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1726 of 2345
Analytical Competencies
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this

The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes.

Familiarize students with main architectural principles and concepts of embedded control systems.

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

151-0532-00L Nonlinear Dynamics and Chaos I W 4 credits 2V+2U G. Haller

Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.

(2) Near equilibrium dynamics: Linear and Lyapunov stability

(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations

(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.

(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Personal Competencies
Creative Thinking

Critical Thinking

151-0593-00L Embedded Control Systems W 4 credits 6G C. Onder, M. Schmid Daners

Abstract
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

Objective
Familiarize students with main architectural principles and concepts of embedded control systems. An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Content
Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Lecture notes
Lecture notes, lab instructions, supplemental material

Prerequisites / notice
- Prerequisites: Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marisch@gmail.ethz.ch).

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

151-0605-00L Nanosystems W 4 credits 4G A. Stemmer

Abstract
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.

Objective
Familiarize students with basic science and engineering principles governing the nano domain.
The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale
Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures.

**Literature**

**Prerequisites / notice**
Lectures and Mini-Review presentations: Thursday 10-13
Homework: Mini-Review
(compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.
Content
The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

Lecture notes
The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

Literature
The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Prerequisites / notice

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>W</th>
<th>6 credits</th>
<th>3V+2U</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>J. Lygeros, A. Tsiamis</td>
</tr>
<tr>
<td>227-0311-00L</td>
<td>Qubits, Electrons, Photons</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>

Abstract

Content
- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Objective

Objective

Sufficient mathematical maturity, in particular in linear algebra, analysis.

Objective

CONTENT

Identical Particles: Bosons and Fermions
Harmonic Oscillator: Creation and Annihilation Operators
Symmetries and Corresponding Operators
Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
Postulates of QM: Hilbert Spaces and Operators
Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
Density Operator
Spin: Qubits, Bloch Equations, and NMR
Entanglement

Lecture notes
No lecture notes because the proposed textbook together with the provided supplementary material are more than exhaustive!

Lecture notes
Not assessed

Prerequisites / notice
Available on the course Moodle platform.

Notice
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Notice

- (as rigorous and profound presentation of the mathematical framework) G. Dell'Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer
- (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.

Supplementary material will be uploaded in Moodle.

Supplementary material will be uploaded in Moodle.

Supplementary material will be uploaded in Moodle.

Prerequisites / notice

- Sufficient mathematical maturity, in particular in linear algebra, analysis.
- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
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- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Notice

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Prerequisites / notice

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

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Data: 18.08.2022 12:39
Autumn Semester 2022
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This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

Suitable for Master Students as well as Doctoral Students.

**227-0468-00L Analog Signal Processing and Filtering**

**W 6 credits 2V+2U**  
**H. Schmid**

### Abstract

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

### Objective

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

### Lecture notes

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

**Prerequisites / notice**

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.
Emerging Memory Technologies

The course covers the status and prospects of post-silicon memory technologies, such as PCM, MRAM, STT-MRAM and FeRAM, and others. Students learn and compare these memory technologies by means of interactive lectures, group projects, and laboratory sessions. The course employs constructive alignment and active learning teaching concepts.

Objective

Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict them at least niche applications for ever-growing hardware market. However, some of technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now.

Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other’s. Selecting to study one technology in more details, students will evaluate its potential and acquire important presenting and critical thinking skills.

Content

The course is organized as a series of lectures, which are synchronized with student group projects, focusing on selected memory technologies. Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 5 presentations (20-25 min each), followed the example given by the lecturer.

Literature

Lecture notes will be made available on the website.

Quantum Science with Superconducting Circuits

Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.

Objective

Based on today’s most advanced solid state platform for quantum control, the students will learn how to engineer quantum coherent devices and how to use them to process quantum information. The students will acquire both analytical and numerical methods to model the properties and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.

Content


Prerequisites / notice

- All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

Methods which are covered embrace: Gas adsorption and surface area analysis, IR-Spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, X-ray absorption, solid state NMR, Electron Microscopy and others.

Process Design and Development

The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

Objective

The course is focused on the design of Chemical Processes, with emphasis on the preliminary stage of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

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### Content
- Process creation: heuristics vs. mathematical programming.
- Heuristics for reaction and separation operations, heat transfer and pressure change.
- Introduction to optimization in process engineering and the modeling software GAMS.
- Process economic evaluation: equipment sizing and costing, time value of money, cash flow calculations.
- Process environmental evaluation: Life Cycle Assessment (LCA).
- Process integration: sequencing of distillation columns using mixed-integer linear programming (MILP), and synthesis of heat exchanger networks using mixed-integer nonlinear programming (MINLP).
- Batch processes: scheduling, sizing, and inventories.
- Principles of molecular design using mixed-integer programming.

### Lecture notes
- no script

### Literature
**Main books**

**Other references**

**Prerequisites / notice**
- Prerequisite: Basic knowledge on unit operations, mainly reaction engineering and distillation. It is recommended that the student takes the module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

### 701-1239-00L Aerosols I: Physical and Chemical Principles

**Abstract**
Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

**Objective**
- Physical and chemical principles:
  - The students...
  - know the processes and physical laws of aerosol dynamics.
  - understand the thermodynamics of phase equilibria and chemical equilibria.
  - know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

- Experimental methods:
  - know the most important chemical and physical measurement instruments.
  - understand the underlying chemistry and physics.

- Environmental impacts:
  - know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
  - know the most important climate impacts of atmospheric aerosols.

- are aware of the health impacts of atmospheric aerosols.

**Lecture notes**
- materiel is distributed during the lecture

**Literature**

**Taught competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed
- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed
- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: assessed
  - Critical Thinking: not assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

### 752-3103-00L Food Rheology I

**Abstract**
Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.
Objective
The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

Content
Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

Lecture notes
Notes will be handed out during the lectures.

Literature
Provided in the lecture notes.

► Multidisciplinary Courses
The students are free to choose individually from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

► Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

see Science in Perspective: Language Courses ETH/UZH

► Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-1007-00L</td>
<td>Semester Project Micro- and Nanosystems</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

The subject of the Semester Project and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

Abstract
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

► Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>151-1090-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>8 credits</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

No registration required via myStudies.

Abstract
The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Objective
The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

► Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tr>
<td>151-1006-00L</td>
<td>Master's Thesis Micro- and Nanosystems</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Students who fulfill the following criteria are allowed to begin with their Master's Thesis:
- a. successful completion of the bachelor program;
- b. fulfilling of any additional requirements necessary to gain admission to the master program;
- c. successful completion of the semester project;
- d. achievement of 32 ECTS in the category "Core Courses".

The Master's Thesis must be approved in advance by the tutor and is supervised by a professor of ETH Zurich.

Abstract
Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

Objective
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

Micro- and Nanosystems Master - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>
Exchange Students

Courses for Exchange Students

Prepare a study plan
In case the course catalogue of the upcoming semester is not available yet, please expect it to be like the year before.
You can study at ETH Zurich as an exchange student for 1 or 2 semesters, starting in the autumn or in the spring semester.
Exchange students may choose courses from different curricula and years, provided that at least two thirds of all courses are taken in the ETH Zurich department they are registered in. Please be sure to coordinate your schedule with your home university.

Exam sessions and End-of-semester examinations
Like all ETH Zurich students, exchange students are obliged to sit their exams during the official examination periods. Students are requested to be present at ETH Zurich during these periods. You are therefore expected to plan your studies, internships, jobs, and financial means accordingly.

Research Project

The courses below are only available for exchange students.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td></td>
<td>ONLY for mobility students. Any other students (e.g.BSc, MSc, doctoral students) CANNOT enrol for this course unit.</td>
<td></td>
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<tr>
<td></td>
<td>Independent project of 1 month, supervised by a professor</td>
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<td>900-0010-00L</td>
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<td>W</td>
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<td>ONLY for mobility students. Any other students (e.g.BSc, MSc, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td></td>
<td>Independent project of 2 months, supervised by a professor</td>
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<tr>
<td>900-0015-00L</td>
<td>15 Credit Project</td>
<td>W</td>
<td>15 credits</td>
<td>32A</td>
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<td></td>
<td>ONLY for mobility students. Any other students (e.g.BSc, MSc, doctoral students) CANNOT enrol for this course unit.</td>
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<td>Independent project of 5 months, supervised by a professor</td>
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<td>900-0030-00L</td>
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<tr>
<td>900-0060-00L</td>
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<td>129A</td>
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<td>ONLY for mobility students. Any other students (e.g.BSc, MSc, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td></td>
<td>Independent project of 1 year, supervised by a professor</td>
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</table>

Additional Courses

by individual arrangement

Exchange Students - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium | | |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Neural Systems and Computation Master

Core Courses

Compulsory Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1039-00L</td>
<td>Basics of Instrumentation, Measurement, and Analysis (University of Zurich)</td>
<td>O</td>
<td>4</td>
<td>9S</td>
<td>S.-C. Liu, T. Delbrück, R. Hahnloser, G. Indiveri, V. Mante, P. Pyk, D. Scaramuzza, W. von der Behrens</td>
</tr>
</tbody>
</table>

**Abstract**

Experimental data are always as good as the instrumentation and measurement, but never any better. This course provides the very basics of instrumentation relevant to neurophysiology and neuromorphic engineering, it consists of two parts: a common introductory part involving analog signals and signal acquisition (Part I), and a more specialized second part (Part II).

**Objective**

The goal of Part I is to provide a general introduction to the signal acquisition process. Students are familiarized with basic lab equipment such as oscilloscopes, function generators, and data acquisition devices. Different electrical signals are generated, visualized, filtered, digitized, and analyzed using Matlab (Mathworks Inc.) or Labview (National Instruments).

In Part II, the students are divided into small groups to work on individual measurement projects according to availability and interest. Students single-handedly solve a measurement task, making use of their basic knowledge acquired in the first part. Various signal sources will be provided.

**Prerequisites / notice**

For each part, students must hand in a written report and present a live demonstration of their measurement setup to the respective supervisor. The supervisor of Part I is the teaching assistant, and the supervisor of Part II is task specific. Admission to Part II is conditional on completion of Part I (report + live demonstration).

Reports must contain detailed descriptions of the measurement goal, the measurement procedure, and the measurement outcome. Either confidence or significance of measurements must be provided. Acquisition and analysis software must be documented.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-1031-00L</td>
<td>Journal Club (University of Zurich)</td>
<td>O</td>
<td>2</td>
<td>1S</td>
<td>G. Indiveri</td>
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</tbody>
</table>

**Abstract**

The Neuroinformatics Journal club is a weekly meeting during which students present current research papers. The presentation last from 30 to 60 Minutes and is followed by a general discussion.

**Objective**

The Neuroinformatics Journal club aims to train students to present cutting-edge research clearly and efficiently. It leads students to learn about current topics in neurosciences and neuroinformatics, to search the relevant literature and to critically and scholarly appraise published papers. The students learn to present complex concepts and answer critical questions.

Content

Relevant current papers in neurosciences and neuroinformatics are covered.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1043-00L</td>
<td>Neuroinformatics - Colloquia (University of Zurich)</td>
<td>Z</td>
<td>0</td>
<td>1K</td>
<td>S.-C. Liu, R. Hahnloser, V. Mante</td>
</tr>
</tbody>
</table>

**Abstract**

The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.

**Objective**

The goal of these talks is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.

Content

The topics depend heavily on the invited speakers, and thus change from week to week. All topics concern neural computation and their implementation in biological or artificial systems.

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-1045-00L</td>
<td>Readings in Neuroinformatics (University of Zurich)</td>
<td>O</td>
<td>3</td>
<td>1S</td>
<td>W. von der Behrens, R. Hahnloser, S.-C. Liu, V. Mante</td>
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</table>

**Abstract**

Thirteen major areas of research have been selected, which cover the key concepts that have led to our current ideas of how the nervous system is built and functions. We will read both original papers and explore the conceptual links between them and discuss the 'sociology' of science, the pursuit of basic science questions over a century of research.
Objective

It is commonplace that scientists rarely cite literature that is older than 10 years and when they do, they usually cite one paper that serves as the representative for a larger body of work that has long since been incorporated anonymously in textbooks. Even worse, many authors have not even read the papers they cite in their own publications. This course, ‘Foundations of Neuroscience’ is one antidote. Thirteen major areas of research have been selected. They cover the key concepts that have led to our current ideas of how the nervous system is built and functions. Unusually, we will explore these areas of research by reading the original publications, instead of reading a digested summary from a textbook or review. By doing this, we will learn how the discoveries were made, what instrumentation was used, how the scientists interpreted their own findings, and how their work, often over many decades and linked together with related findings from many different scientists, generate the current views of mechanism and structure of the nervous system. We will read different original papers and explore the conceptual links between them and discuss the ‘sociology’ of science. We will also explore the personalities of the scientists and the context in which they made their seminal discoveries. Each week, course members will be given original papers to read for homework and they will write a short abstract for each paper. We will then meet weekly with the course leader and an assistant for an hour-or-so long interactive seminar. An intimate knowledge of the papers will be assumed so that the discussion does not center simply on an explication of the contents of the papers. Assessment will be in the form of a written exam where students will be given a paper and asked to write a short abstract of its contents.

Content

It is commonplace that scientists rarely cite literature that is older than 10 years and when they do, they usually cite one paper that serves as the representative for a larger body of work that has long since been incorporated anonymously in textbooks. Even worse, many authors have not even read the papers they cite in their own publications. This course, ‘Foundations of Neuroscience’ is one antidote. Thirteen major areas of research have been selected. They cover the key concepts that have led to our current ideas of how the nervous system is built and functions. Unusually, we will explore these areas of research by reading the original publications, instead of reading a digested summary from a textbook or review. By doing this, we will learn how the discoveries were made, what instrumentation was used, how the scientists interpreted their own findings, and how their work, often over many decades and linked together with related findings from many different scientists, generate the current views of mechanism and structure of the nervous system. We will read different original papers and explore the conceptual links between them and discuss the ‘sociology’ of science. We will also explore the personalities of the scientists and the context in which they made their seminal discoveries. Each week, course members will be given original papers to read for homework and they will write a short abstract for each paper. We will then meet weekly with the course leader and an assistant for an hour-or-so long interactive seminar. An intimate knowledge of the papers will be assumed so that the discussion does not center simply on an explication of the contents of the papers. Assessment will be in the form of a written exam where students will be given a paper and asked to write a short abstract of its contents.

Elective Core Courses

Systems Neurosciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0421-00L</td>
<td>Deep Learning in Artificial and Biological Neuronal Networks</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>B. Grewe</td>
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</tbody>
</table>

Abstract

Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Content

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al., 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more efficiently with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training, on the one side seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Lecture notes

The lecture slides will be provided as a PDF after each lecture.

Prerequisites / notice

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate statistics, probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).

2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1737 of 2345
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

**Neural Computation and Theoretical Neurosciences**

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<thead>
<tr>
<th>Number</th>
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<tr>
<td>227-1051-00L</td>
<td>Systems Neuroscience (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>D. Kiper, M. Cook, B. Grewe, W. von der Behrens</td>
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</table>

Abstract: This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions. To understand the basic concepts underlying perceptual, motor and cognitive functions.

Objective: Main emphasis sensory systems, with complements on motor and cognitive functions.

Content: This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

**Deep Learning in Artificial and Biological Neuronal Networks**

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+1A</td>
<td>V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens</td>
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</table>

Abstract: The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective: Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural function. The main goal of this introductory course is to introduce the monocultures of physics, math, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content: This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

**Deep Learning in Artificial and Biological Neuronal Networks**

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<td>227-0421-00L</td>
<td>Deep Learning in Artificial and Biological Neuronal Networks</td>
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<td>3G</td>
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Objective: The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

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Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on J. Vörös and T. Delbrück.

**Neurotechnologies and Neuromorphic Engineering**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U+1A</td>
<td>V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens</td>
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</table>

**Abstract**
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

**Objective**
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enigmas and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

**Content**
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the actions of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

<table>
<thead>
<tr>
<th>Number</th>
<th>Neuronomorphic Engineering I</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuronomorphic Engineering I</td>
<td>W</td>
<td>6 credits</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu</td>
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</tbody>
</table>

**Abstract**
This course covers analog circuits with emphasis on neuronomorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**
Understanding the characteristics of neuronomorphic circuit elements.

**Content**
Neuronomorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuronomorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuronomorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuronomorphic circuits, from elementary devices to systems.

**Prerequisites / notice**
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

**Bioelectronics and Biosensors**

<table>
<thead>
<tr>
<th>Number</th>
<th>Bioelectronics and Biosensors</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0393-00L</td>
<td>Bioelectronics and Biosensors</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>J. Vörös, M. F. Yanki</td>
</tr>
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</table>

**Abstract**
The course introduces the concepts of bioelectricity and biosensing. The sources and use of electrical fields and currents in the context of biological systems and problems are discussed. The fundamental challenges of measuring biological signals are introduced. The most important biosensing techniques and their physical concepts are introduced in a quantitative fashion.

**Objective**
- During this course the students will:
  - learn the basic concepts in biosensing and bioelectronics
  - be able to solve typical problems in biosensing and bioelectronics
  - learn about the remaining challenges in this field
L1. Bioelectronics history, its applications and overview of the field
- Volta and Galvani dispute
- BMI, pacemaker, cochlear implant, retinal implant, limb replacement devices
- Fundamentals of biosensing
- Glucometer and ELISA
L2. Fundamentals of quantum and classical noise in measuring biological signals
L3. Biomeasurement techniques with photons
L4. Acoustics sensors
- Differential equation for quartz crystal resonance
- Acoustic sensors and their applications
L5. Engineering principles of optical probes for measuring and manipulating molecular and cellular processes
L6. Optical biosensors
- Differential equation for optical waveguides
- Optical sensors and their applications
- Plasmonic sensing
L7. Basic notions of molecular adsorption and electron transfer
- Quantum mechanics: Schrödinger equation energy levels from H atom to crystals, energy bands
- Electron transfer: Marcus theory, Gerischer theory
L8. Potentiometric sensors
- Fundamentals of the electrochemical cell at equilibrium (Nernst equation)
- Principles of operation of ion-selective electrodes
L9. Amperometric sensors and bioelectric potentials
- Fundamentals of the electrochemical cell with an applied overpotential to generate a faraday current
- Principles of operation of amperometric sensors
- Ion flow through a membrane (Pfick equation, Nernst equation, Donnan equilibrium, Goldman equation)
L10. Channels, amplification, signal gating, and patch clamp Y4
L11. Action potentials and impulse propagation
L12. Functional electric stimulation and recording
- MEA and CMOS based recording
- Applying potential in liquid - simulation of fields and relevance to electric stimulation
L13. Neural networks memory and learning

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, Michaelis-Menten equation, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>401-0151-00L</td>
<td>Linear Algebra</td>
<td>W</td>
<td>5</td>
<td>3V+2U</td>
<td>V. C. Gradinaru</td>
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<tr>
<td>Abstract</td>
<td>Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.</td>
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<tr>
<td>Objective</td>
<td>Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte</td>
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<td>Lecture notes</td>
<td>eigenes Aufschrieb und K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, S. Auflage 2002</td>
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<td>K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, S. Auflage 2002</td>
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<td>Taught competencies</td>
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<td>Methods-specific Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Personal Competencies</td>
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<td></td>
<td></td>
<td>Cooperation and Teamwork</td>
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</table>

| 401-0603-00L| Stochastics (Probability and Statistics) | W    | 4    | 2V+1U | P. Cheridito       |
| Abstract    | The following concepts are covered: probabilities, random variables, probability distributions, joint and conditional probabilities and distributions, law of large numbers, central limit theorem, descriptive statistics, statistical inference, parameter estimation, confidence intervals, statistical tests, two-sample tests, linear regression. |      |      |       |                   |
| Objective   | Knowledge of the basic principles of probability theory and statistics. |      |      |       |                   |
| Content     | Introduction to probability theory and statistics. |      |      |       |                   |

| 401-2813-00L| Programming Techniques for Scientific Simulations I | W    | 5    | 4G   | R. Käppeli         |
| Abstract    | This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained. |      |      |       |                   |
| Objective   | The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations. |      |      |       |                   |
Course: Introduction to Computational Physics

**Objective**

Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**

Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

**Literature**

Lecture notes and slides are available online and will be distributed if desired.

**Prerequisites / Notice**

Lecture notes and exercises in English, exams in German or in English

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Course: Electron Microscopy in Material Science

**Abstract**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Objective**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Content**

This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

**Literature**


Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

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Course: Medical Physics I

**Abstract**

Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

**Objective**

Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

**Content**

The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

**Literature**

A script will be provided.

**Prerequisites / Notice**

For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

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Course: Consciousness: From Philosophy to Neuroscience

**Abstract**

This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained. Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

**Objective**

The course’s goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought by modern cognitive neuroscience. We aim to clarify concepts, explain their philosophical and scientific backgrounds, and to present experimental protocols that shed light on a variety of consciousness related issues.

**Content**

The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of consciousness, and proposals for the neural correlate of consciousness (NCC).

**Literature**

We display articles pertaining to the issues we cover in the class on the course’s webpage.

Since we are all experts on consciousness, we expect active participation and discussions!

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Course: Physics in Medical Research: From Atoms to Cells

**Abstract**

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxido and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.
Master's Thesis and Semester Papers/Seminars

Option 1: Long Master's Thesis

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>NSC Master's Thesis (long) and Exam (University of Zurich)</td>
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<td>M. F. Yanik</td>
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No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI503

Mind the enrolment deadlines at UZH:

Only students who fulfill the following criteria are allowed to begin with their master thesis:
(a) successful completion of the bachelor programme;
(b) fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
The Master thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective
see above

Option 2: Short Master's Thesis and Semester Papers/Seminars

Short Master Thesis

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1041-02L</td>
<td>NSC Master's Thesis (short) and Exam (University of Zurich)</td>
<td>W</td>
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<td>M. F. Yanik</td>
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</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI504


Only students who fulfill the following criteria are allowed to begin with their master thesis:
(a) successful completion of the bachelor programme;
(b) fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
The Master thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective
see above

Semester Papers/Seminars

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>227-1036-01L</td>
<td>NSC Master Short Project I (University of Zurich)</td>
<td>W</td>
<td>8</td>
<td>17A</td>
<td>M. F. Yanik</td>
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No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI505

Mind the enrolment deadlines at UZH:

Abstract
Usually a student selects the topic of a Master Short Project in consultation with his or her mentor.

Objective
see above

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<th>Number</th>
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<tr>
<td>227-1036-02L</td>
<td>NSC Master Short Project II (University of Zurich)</td>
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No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI506

Mind the enrolment deadlines at UZH:

Abstract
Usually a student selects the topic of a Master Short Project in consultation with his or her mentor.

Objective
see above

Neural Systems and Computation Master - Key for Type

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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1743 of 2345
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<tr>
<td>V</td>
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<td>lecture with exercise</td>
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<td>U</td>
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<td>independent project</td>
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<td>S</td>
<td>seminar</td>
<td>D</td>
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<tr>
<td>K</td>
<td>colloquium</td>
<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Nuclear Engineering Master
MSc Nuclear Engineering is a joint program of EPF Lausanne and ETH Zurich. The first semester takes place in Lausanne. Students therefore have to enroll at EPFL.
For more information about the curriculum and courses see: http://master.epfl.ch/cms/site/master/lang/en/nuclearengineering

Core Courses

1. Semester (EPFL)

<table>
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<th>Number</th>
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<td>151-2011-00L</td>
<td>Physics of Nuclear Reactors (EPFL)</td>
<td>O</td>
<td>6</td>
<td>6G</td>
<td>external organisers</td>
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<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.</td>
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<tr>
<td>Abstract</td>
<td>In this course, one acquires an understanding of the basic neutronics interactions occurring in a nuclear fission reactor and, as such, the conditions for establishing and controlling a nuclear chain reaction.</td>
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<td>Objective</td>
<td>By the end of the course, the student must be able to:</td>
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<tr>
<td>- Elaborate on neutron diffusion equation</td>
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<td>- Systematize nuclear reaction cross sections</td>
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<tr>
<td>- Formulate approximations to solving the diffusion equation for simple systems</td>
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<td>Content</td>
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<tr>
<td>- Brief review of nuclear physics</td>
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<td>- Historical: Constitution of the nucleus and discovery of the neutron - Nuclear reactions and radioactivity - Cross sections - Differences between fusion and fission.</td>
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<td>- Nuclear fission</td>
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<td>- Characteristics - Nuclear fuel - Introductory elements of neutronics.</td>
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<td>- Fissile and fertile materials - Breeding.</td>
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<td>- Neutron diffusion and slowing down</td>
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<td>- Monoenergetic neutrons - Angular and scalar flux</td>
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<td>- Diffusion theory as simplified case of transport theory - Neutron slowing down through elastic scattering.</td>
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<tr>
<td>- Multiplying media (reactors)</td>
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<td>- Multiplication factors - Criticality condition in simple cases.</td>
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<td>- Reactor kinetics</td>
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<td>- Point reactor model: prompt and delayed transients - Practical applications.</td>
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<td>- Reactivity variations and control</td>
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<td>- Short, medium and long term reactivity changes ? Different means of control.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisite for: Reactor Experiments</td>
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<thead>
<tr>
<th>Number</th>
<th>Radiation and Reactor Experiments (EPFL)</th>
<th>O</th>
<th>6</th>
<th>4G</th>
<th>external organisers</th>
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<td>151-2013-00L</td>
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<tr>
<td>Abstract</td>
<td>To gain hands-on experience in the conduction of nuclear radiation measurements, as also in the execution and analysis of reactor physics experiments using the CROCUS reactor.</td>
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<tr>
<td>Objective</td>
<td>To gain hands-on experience in the conduction of nuclear radiation measurements, as also in the execution and analysis of reactor physics experiments using the CROCUS reactor.</td>
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<tr>
<td>Content</td>
<td>- Radiation detector systems, alpha and beta particles</td>
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<tr>
<td>- Radiation detector systems, gamma spectroscopy</td>
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<tr>
<td>- Introduction to neutron detectors (He-3, BF3)</td>
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<td>- Slowing-down area (Fermi age) of Pu-Be neutrons in H2O</td>
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<td>- Approach-to-critical experiments</td>
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<td>- Buckling measurements</td>
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<td>- Reactor power calibration</td>
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<tr>
<td>- Control rod calibration</td>
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<td>Prerequisites / notice</td>
<td>Prerequisite for: Special Topics in Reactor Physics (2nd sem.)</td>
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<tr>
<th>Number</th>
<th>Reactor Technology (EPFL)</th>
<th>O</th>
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<th>3G</th>
<th>A. Manera, external organisers</th>
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<tr>
<td>151-2015-00L</td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.</td>
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<tr>
<td>Abstract</td>
<td>Basic heat removal phenomena in a reactor core, limits for heat generation and technological consequences arising from fuel, cladding and coolant properties, main principles of reactor thermal design, as well as the general design of the nuclear power plant with its main and auxiliary systems are explained. The system technology of the most important thermal and fast reactor types is introduced.</td>
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<tr>
<td>Objective</td>
<td>By the end of the course, the student must be able to: (1) Understand design principles of nuclear reactors, (2) Understand purpose and function of main reactor and power plant components and subsystems, (3) assess and evaluate the performance of reactor types, (4) systematize reactor system components, (5) formulate safety requirements for reactor systems</td>
<td></td>
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</tbody>
</table>
Content
- Fuel rod, LWR fuel elements
- Temperature field in fuel rod
- Reactor core, design
- Flux and heat source distribution, cooling channel
- Single-phase convective heat transfer, axial temperature profiles
- Boiling crisis and DNB ratio
- Pressurized water reactors, design
- Primary circuit design
- Steam generator heat transfer, steam generator types
- Boiling water reactors
- Reactor design
- LWR power plant technology, main and auxiliary systems
- Breeding and transmutation, purpose of generation IV systems
- Properties of different coolants and technological consequences
- Introduction into gas-cooled reactors, heavy water moderated reactors, sodium and led cooled fast reactors, molten salt reactors, accelerator driven systems

Literature
Distributed documents, recommended book chapters

Prerequisites / notice
Required prior knowledge: Neutronics
Prerequisite for: Nuclear Safety (2nd sem.)

151-2043-00L Radiation Biology, Protection and Applications (EPFL) O 4 credits 3G external organisers

Abstract
An introductory course in the basic concepts of radiation detection and interactions and energy deposition by ionizing radiation in matter, radioisotope production and its applications in medicine, industry and research. The course includes presentations, lecture notes, problem sets and seminars.

Objective
By the end of the course, the student must be able to:

- Explain the basic physics principles that underpin radiotherapy, e.g. types of radiation, atomic structure, etc.
- Explain the interaction mechanisms of ionizing radiation at keV and MeV energies with matter.
- Explain the principles of radiation dosimetry.
- Explain the principles of therapeutic radiation physics including X-rays, electron beam physics, radioactive sources, use of unsealed sources and Brachytherapy.
- Describe how to use radiotherapy equipment both for tumour localisation, planning and treatment.
- Define quality assurance and quality control, in the context of radiotherapy and the legal requirements.
- Explain the principles and practice of radiation protection, dose limits, screening and protection mechanisms.
- Explain the use of radiation in industrial and research applications.

Content
Basics: radiation sources and interaction with matter, radioisotope production using reactors and accelerators, radiation protection and shielding.
Medical applications: diagnostic tools, radiopharmaceuticals, cancer treatment methodologies such as brachytherapy, neutron capture therapy and proton therapy.
Industrial applications: radiation gauges, radiochemistry, tracer techniques, radioisotope batteries, sterilization, etc.
Applications in research: dating by nuclear methods, applications in environmental and life sciences, etc.

151-2021-00L Hydraulic Turbomachines (EPFL) W 4 credits 4G external organisers

Abstract
Mastering the scientific design of a hydraulic machine, pump and turbine, by using the most advanced engineering design tools. For each chapters the theoretical basis are first established and then practical solutions are discussed with the help of recent design examples.

Objective
Mastering the scientific design of a hydraulic machine, pump and turbine, by using the most advanced engineering design tools. For each chapters the theoretical basis are first established and then practical solutions are discussed with the help of recent design examples.

Content
- Turbomachine equations, mechanical power balance in a hydraulic machines, moment of momentum balance applied to the runner/impeller, generalized Euler equation.
- Hydraulic characteristic of a reaction turbine, a Pelton turbine and a pump, losses and efficiencies of a turbomachine, real hydraulic characteristics.
- Similitude laws, non dimensional coefficients, reduced scale model testing, scale effects.
- Cavitation, hydraulic machine setting, operating range, adaptation to the piping system, operating stability, start stop transient operation, runaway.
- Reaction turbine design: general procedure, general project layout, design of a Francis runner, design of the spiral casing and the distributor, draft tube role, CFD validation of the design, design fix, reduced scale model experimental validation.
- Pelton turbine design: general procedure, project layout, injector design, bucket design, mechanical problems.
- Centrifugal pump design: general architecture, energetic loss model in the diffuser and/or the volute, volute design, operating stability.

Literature
Notes de cours polycopiées et littérature spécialisée (IMHEF, industrie, associations scientifiques, congrés, etc.).
Titre / Title
Hydraulic turbomachines (ME-453)
Matière
Prérequis:
Mécanique des milieux continus; Introduction aux turbomachines.
Préparation pour:
Choix des équipements hydrauliques; Projets et travail pratique de Master
**Nuclear Fusion and Plasma Physics (EPFL)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

**Abstract**
The goal of the course is to provide the physics and technology basis for controlled fusion research, from the main elements of plasma physics to the reactor concepts.

**Objective**
By the end of the course, the student must be able to:
- Design the main elements of a fusion reactor
- Identify the main physics challenges on the way to fusion
- Identify the main technological challenges of fusion

**Content**
1) Basics of thermonuclear fusion
2) The plasma state and its collective effects
3) Charged particle motion and collisional effects
4) Fluid description of a plasma
5) Plasma equilibrium and stability
6) Magnetic confinement: Tokamak and Stellarator
7) Waves in plasma
8) Wave-particle interactions
9) Heating and non inductive current drive by radio frequency waves
10) Heating and non inductive current drive by neutral particle beams
11) Material science and technology: Low and high Temperature superconductor - Properties of material under irradiation
12) Some nuclear aspects of a fusion reactor: Tritium production
13) Licensing a fusion reactor: safety, nuclear waste
14) Inertial confinement

**Literature**

**Prerequisites / notice**
Required prior knowledge:
Basic knowledge of electricity and magnetism, and of simple concepts of fluids

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**Introduction to Particle Accelerators (EPFL)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

**Abstract**
The course presents basic physics ideas underlying the workings of modern accelerators. We will examine key features and limitations of these machines as used in accelerator driven sciences like high energy physics, materials and life sciences.

**Objective**
By the end of the course, the student must be able to:
- Design basic linear and non-linear charged particles optics
- Elaborate basic ideas of physics of accelerators
- Use a computer code for optics design
- Optimize accelerator design for a given application
- Estimate main beam parameters of a given accelerator

**Content**
Overview, history and fundamentals
Transverse particle dynamics (linear and nonlinear)
Longitudinal particle dynamics
Linear accelerators
Circular accelerators
Acceleration and RF-technology
Beam diagnostics
Accelerator magnets
Injection and extraction systems
Synchrotron radiation

**Literature**
Recommended during the course

**Prerequisites / notice**
Prérequis: Notion de relativité restreinte et d'électrodynamique

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**Introduction to Medical Radiation Physics (EPFL)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

**Abstract**
This course covers the physical principles underlying medical imaging using ionizing radiation (radiography, fluoroscopy, CT, SPECT, PET).

**Objective**
The focus is not only on risk and dose to the patient and staff, but also on an objective description of the image quality.

**Content**
Physics of radiography: X-ray production, Radiation-patient interaction, Image detection and display
Image quality: Wagner's taxonomy, MTF, NPS, contrast, SNR, DQE, NEQ, CNR
Dose to the patient: External irradiation, Internal contamination, compartmental models
Physics of computer tomography (CT)
Risk and radiation: Rational risk and state of our knowledge, Psychological aspects, Ethics and communication
Physics of single-photon emission computed tomography (SPECT)
Physics of mammography
Receiver operating characteristics (ROC) and hypothesis testing: Link between medical diagnostic and statistical hypothesis testing, Sensitivity, specificity, prevalence, predictive values
Physics of radioscopy
Model observers in medical imaging: Human visual characteristics and their quantification, Bayesian cost and Ideal model observer, Anthropomorphic model observers, Detection experiments (rating, M-AFC, yes-no)
Physics of positron emission tomography (PET)
Physics of resonance magnetic imaging

---

**Energy Conversion and Renewable Energy (EPFL)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

**Objective**
- Physics of computer tomography (CT)
- Risk and radiation: Rational risk and state of our knowledge, Psychological aspects, Ethics and communication
- Physics of single-photon emission computed tomography (SPECT)
- Physics of mammography
- Receiver operating characteristics (ROC) and hypothesis testing: Link between medical diagnostic and statistical hypothesis testing, Sensitivity, specificity, prevalence, predictive values
- Physics of radioscopy
- Model observers in medical imaging: Human visual characteristics and their quantification, Bayesian cost and Ideal model observer, Anthropomorphic model observers, Detection experiments (rating, M-AFC, yes-no)
- Physics of positron emission tomography (PET)
- Physics of resonance magnetic imaging

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**Autumn Semester 2022**
corresponding module directly at EPFL.

Abstract
By the end of the course, the student must be able to:
- Elaborate morphological filters
- Construct image-processing software
- Apply image-analysis techniques
- Design digital filters in 2-D
- Formalize convolution and optical systems
- Optimize 2-D sampling to avoid aliasing
- Select appropriately Hilbert spaces and inner-products
- Exploit the multidimensional Fourier transform

Content
- Structural characterization: RX, electron diffraction, ...
- Scanning probe microscopy (SPM): Principles of operation of the scanning tunneling microscope and atomic force microscope
- Optical spectroscopies: The elements of a modern spectroscopy system; different methods of spectral dispersion and their advantages
- Electron microscopy: Transmission and scanning microscopes, their principles of operation, observation techniques, uses ...

Objective
- Integrate urban systems
- Storage of energy: Batteries, compressed air, pumped hydro, thermal storage
- Fuel cells and hydrogen as energy vector
- Renewable energy vectors, their physical principles and essential equations:
- Solar (photovoltaics and thermal - collectors/concentrators), geothermal, biomass (a.o. gasification, biogases, liquid biofuels), hydro, wind

Prerequisites
- Required courses: Physics I and Physics II

Important concepts to start the course: Conservation principles (energy, mass, momentum)

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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<td>151-2053-00L</td>
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<td>151-2055-00L</td>
<td>Image Processing I (EPFL)</td>
<td>3</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1748 of 2345
This course will present an overview of the nuclear interactions for neutrons on nuclei below a few hundreds of MeV. The aspect of so
Concepts of Computer Aided Process System Engineering methods to tackle the problems of energy conversion systems modelling and
The application of the neutron scattering spans from crystalline matter to bio-materials and engineering, including fields like magnetism and
Neutron Scattering - Theory and Applications (EPFL)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.
Abstract
The goal of the lecture is to present and apply techniques for the modelling and the thermo-economic optimisation of industrial process and energy systems. The lecture covers the problem statement, the solving methods for the simulation and the single and multi-objective optimisation problems.
Objective
By the end of the course, the student must be able to:
- Master the concepts of thermodynamic efficiency, E6
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E22
- Analyse the energy and exergy efficiency of industrial energy systems, E23
- Model, design and optimize energy conversion systems and industrial processes, E24
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E20
- Explain and apply the concepts of thermodynamic efficiency, E6
- Analyse the energy and exergy efficiency of industrial energy systems, E21
- Model , design and optimize energy conversion systems and industrial processes, E22
Content
- Concepts of Computer Aided Process System Engineering methods to tackle the problems of energy conversion systems modelling and optimisation. The students will acquire a methodology to state the problem, identify the solving procedure, solve the problem and analyse the results;
- Definition of the basic system modelling concepts : state variables, energy and mass balances, simulation parameters and equations, degree of freedom analysis, different types of specifications, inequalities, objective functions;
- Energy systems equipments models;
- System models : flowsheets, degrees of freedom, sequential or simultaneous solving approach, numerical methods and their implications;
- Measurement data reconciliation and parameter identification;
- Calculating systems performances : operation cost, efficiency, environmental impact, investments, thermo-economic and environomic performances;
- Stating and solving optimization problems : decision variables, objective functions and constraints, solving strategies, numerical methods and their implications;
- Realization of a case study.

151-2059-00L Neutron Scattering - Theory and Applications (EPFL) W 4 credits 4G external organisers
No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.
Abstract
Neutron scattering is one of the most powerful and versatile experimental methods to study the structure and dynamics of materials on the nanometer scale. This course covers basic theory, instrumentation and scientific applications.
Objective
The application of the neutron scattering spans from crystalline matter to bio-materials and engineering, including fields like magnetism and superconductivity. Similar to the vast possibilities with X-rays at synchrotron facilities, neutron scattering is a so-called large scale facility technique with neutron facilities among other at PSI in Switzerland, ILL in Grenoble and a new joint European Spallation Source under construction in Sweden.
Content
The course provides an introduction to the versatile experimental techniques of neutron scattering and covers the following aspects:
1) Theory of the neutron scattering cross section
2) Neutron sources and neutron instrumentation
3) Neutron imaging, neutron reflectivity and neutron small angle scattering
4) Neutron diffraction, crystal structures
5) Inelastic neutron scattering, phonons
6) Magnetic neutron scattering, magnetic structures
7) Inelastic magnetic neutron scattering, magnetic dynamics
8) Resonant Inelastic X-ray Scattering (RIXS) a complementary technique
The course contain lectures and exercise sessions. Exercise sessions will contain deriving relevant formulas, monte-carlo simulation of neutron scattering experiments, and discussion of representative scientific articles using neutron scattering.

The course is given every second year, alternating with a course about magnetism in solids.

151-2061-00L Nuclear Interaction : from Reactors to Stars (EPFL) W 4 credits 4G external organisers
No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.
Abstract
This course will present an overview of the nuclear interactions for neutrons on nuclei below a few hundreds of MeV. The aspect of so-called "nuclear data" will be presented from the perspective of experiments, compilation, calculation, evaluation, processing and applications.
Objective
By the end of the course, the student must be able to: Use applications codes.
Content
• Nuclear data needs: It is important to understand if, and where, nuclear data are needed, why, which accuracy is required from the applications or industries. Such needs concerns a large range of applications: energy, medical, waste and astrophysics. Each of these fields requires different knowledge on nuclear interactions with, either with neutrons, or protons, or both.
• Theoretical background: Many of the needs are covered by experimental knowledge, but not all. Some reactions cannot be easily measured, or are simply out of range with current technologies (for instance for with short-lived isotopes). What can we do in this case? Part of the answer relies on theoretical understanding and the prediction power of current models (with their shortcomings). We will then explore (not in details) some of the important models, their range of applications, and what to do when nothing is known.
• Measurement facilities: The current knowledge of nuclear interactions, cross sections and uncertainties is based on measurements. In many instances, measurements are necessary due to the lack of prediction power for models. We will see the existing facilities, their advantages and drawback. We will also visit the installation worldwide, with a view on the future needs.
• Evaluation: Once quantities have been measured or calculated, they need to be presented to potential users. This step is called "evaluation". The outcome of the process is "what the users will see". It covers compiling measurements, combining them with theoretical predictions, formatting, and processing in forms that users need. We will go through these steps, and you will globally understand the importance of these steps.
• Applications: finally, we will see how these nuclear data are used. What are the applications, what are the needs, and how users can propose feedback to influence new measurements, or new calculations.
Particle-based computational methods are being increasingly employed for solving a variety of problems in engineering and applied science. While such methods can yield significant advantages compared to traditional mesh-based methods, their accurate and efficient implementation also provides a number of challenges.

This course presents the fundamental aspects of two methods:

- Material Point Method (MPM) is a hybrid Eulerian-Lagrangian numerical scheme for solving continuum mechanics problems. It is particularly well suited to simulate problems involving large deformations, collisions, fractures and the interaction between different materials (solids, fluids and gases). Material points are used to track the motion and carry information while a background mesh is used to compute spatial gradients.
- Discrete Element Method (DEM) is used for simulating granular and particulate flows and tracks particle motions and detects and models collisions between particles and with their environment. It relies on the equations of Newton and a variety of contact models.

The course provides an introduction to these two methods and their domains of application (e.g. fluid and solid mechanics, computer graphics). The theoretical basis of each method is presented in introductory lectures. Following a literature search, students give oral presentations on a specific article about DEM or MPM and explain more advanced aspects. Mini-project using open-source softwares provide practical experience in the application of these methods. Illustrations of the use of particle-based methods is also provided by researchers from industry and other universities.

**Objective**

By the end of the course, the student must be able to:

- Identify features of a PDE relevant for the selection and performance of a numerical algorithm.
- Assess / Evaluate numerical methods in light of the theoretical results.
- Implement numerical methods for saddle point problems
- Choose an appropriate method to solve a given differential problem
- Prove convergence of a discretisation scheme

**Content**

Particle-based computational methods are being increasingly employed for solving a variety of problems in engineering and applied science. While such methods can yield significant advantages compared to traditional mesh-based methods, their accurate and efficient implementation also provides a number of challenges.

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**Objective**

By the end of the course, the student must be able to:

- Describe the difference between the Eulerian and Lagrangian approaches
- Identify and apply the different steps in a numerical simulation (e.g. geometry and mesh generation, computation, post-processing) and integrate all the essential basic concepts in a numerical flow simulation
- Describe different methods used to discretize differential equations, such as finite differences, finite elements, MPM, SPH, PFEM
- Perform a numerical simulation with appropriate software; understand the limits of each software in terms of its application domain and accuracy of the results obtained

**Content**

Particle-based computational methods are being increasingly employed for solving a variety of problems in engineering and applied science. While such methods can yield significant advantages compared to traditional mesh-based methods, their accurate and efficient implementation also provides a number of challenges.

This course presents the fundamental aspects of two methods:

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- Discrete Element Method (DEM) is used for simulating granular and particulate flows and tracks particle motions and detects and models collisions between particles and with their environment. It relies on the equations of Newton and a variety of contact models.

The course provides an introduction to these two methods and their domains of application (e.g. fluid and solid mechanics, computer graphics). The theoretical basis of each method is presented in introductory lectures. Following a literature search, students give oral presentations on a specific article about DEM or MPM and explain more advanced aspects. Mini-project using open-source softwares provide practical experience in the application of these methods. Illustrations of the use of particle-based methods is also provided by researchers from industry and other universities.

**Objective**

By the end of the course, the student must be able to:

- Manipulate the fundamental elements of the plasma fluid and kinetic theory
- Inelastic collisions: ionization and recombination, degree of ionization
- Elastic collisions: Coulomb collisions
- Isotropisation and thermalisation
- Plasma resistivity and the runaway regime
- Transport in plasmas
- Random walk and diffusion
- Ambipolar and cross-field diffusion
- Energy and particle confinement
- Waves in cold magnetized plasma
- Dielectric tensor
- Resonances and cut-offs
- Parallel and perpendicular propagation
- Wave-particle interaction and kinetic description of waves in hot un-magnetized plasmas
- The Vlasov-Maxwell model
- Resonant wave-particle interaction and Landau damping
- Stability criteria and streaming instabilities
- Langmuir and ion-acoustic waves and instabilities
- Waves in hot magnetized plasmas
- Varieties of nonlinear effects

**Content**

Particle-based computational methods are being increasingly employed for solving a variety of problems in engineering and applied science. While such methods can yield significant advantages compared to traditional mesh-based methods, their accurate and efficient implementation also provides a number of challenges.

This course presents the fundamental aspects of two methods:

- Material Point Method (MPM) is a hybrid Eulerian-Lagrangian numerical scheme for solving continuum mechanics problems. It is particularly well suited to simulate problems involving large deformations, collisions, fractures and the interaction between different materials (solids, fluids and gases). Material points are used to track the motion and carry information while a background mesh is used to compute spatial gradients.
- Discrete Element Method (DEM) is used for simulating granular and particulate flows and tracks particle motions and detects and models collisions between particles and with their environment. It relies on the equations of Newton and a variety of contact models.

The course provides an introduction to these two methods and their domains of application (e.g. fluid and solid mechanics, computer graphics). The theoretical basis of each method is presented in introductory lectures. Following a literature search, students give oral presentations on a specific article about DEM or MPM and explain more advanced aspects. Mini-project using open-source softwares provide practical experience in the application of these methods. Illustrations of the use of particle-based methods is also provided by researchers from industry and other universities.

**Objective**

By the end of the course, the student must be able to:

- Manipulate the fundamental elements of the plasma fluid and kinetic theory
- Inelastic collisions: ionization and recombination, degree of ionization
- Elastic collisions: Coulomb collisions
- Isotropisation and thermalisation
- Plasma resistivity and the runaway regime
- Transport in plasmas
- Random walk and diffusion
- Ambipolar and cross-field diffusion
- Energy and particle confinement
- Waves in cold magnetized plasma
- Dielectric tensor
- Resonances and cut-offs
- Parallel and perpendicular propagation
- Wave-particle interaction and kinetic description of waves in hot un-magnetized plasmas
- The Vlasov-Maxwell model
- Resonant wave-particle interaction and Landau damping
- Stability criteria and streaming instabilities
- Langmuir and ion-acoustic waves and instabilities
- Waves in hot magnetized plasmas
- Varieties of nonlinear effects

**Abstract**

The objective of the course is to give a theoretical and practical knowledge of the finite element method for saddle point problems, such as the ones of fluid dynamics, elasticity and electromagnetic problems.

By the end of the course, the student must be able to:

- Identify features of a PDE relevant for the selection and performance of a numerical algorithm.
- Assess / Evaluate numerical methods in light of the theoretical results.
- Implement numerical methods for saddle point problems
- Choose an appropriate method to solve a given differential problem
- Prove convergence of a discretisation scheme

**Content**

Particle-based computational methods are being increasingly employed for solving a variety of problems in engineering and applied science. While such methods can yield significant advantages compared to traditional mesh-based methods, their accurate and efficient implementation also provides a number of challenges.

This course presents the fundamental aspects of two methods:

- Material Point Method (MPM) is a hybrid Eulerian-Lagrangian numerical scheme for solving continuum mechanics problems. It is particularly well suited to simulate problems involving large deformations, collisions, fractures and the interaction between different materials (solids, fluids and gases). Material points are used to track the motion and carry information while a background mesh is used to compute spatial gradients.
- Discrete Element Method (DEM) is used for simulating granular and particulate flows and tracks particle motions and detects and models collisions between particles and with their environment. It relies on the equations of Newton and a variety of contact models.

The course provides an introduction to these two methods and their domains of application (e.g. fluid and solid mechanics, computer graphics). The theoretical basis of each method is presented in introductory lectures. Following a literature search, students give oral presentations on a specific article about DEM or MPM and explain more advanced aspects. Mini-project using open-source softwares provide practical experience in the application of these methods. Illustrations of the use of particle-based methods is also provided by researchers from industry and other universities.

**Objective**

By the end of the course, the student must be able to:

- Manipulate the fundamental elements of the plasma fluid and kinetic theory
- Inelastic collisions: ionization and recombination, degree of ionization
- Elastic collisions: Coulomb collisions
- Isotropisation and thermalisation
- Plasma resistivity and the runaway regime
- Transport in plasmas
- Random walk and diffusion
- Ambipolar and cross-field diffusion
- Energy and particle confinement
- Waves in cold magnetized plasma
- Dielectric tensor
- Resonances and cut-offs
- Parallel and perpendicular propagation
- Wave-particle interaction and kinetic description of waves in hot un-magnetized plasmas
- The Vlasov-Maxwell model
- Resonant wave-particle interaction and Landau damping
- Stability criteria and streaming instabilities
- Langmuir and ion-acoustic waves and instabilities
- Waves in hot magnetized plasmas
- Varieties of nonlinear effects
Objective

The elective project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

3. Semester (PSI)

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<td>151-0150-00L</td>
<td>Advanced Topics in Nuclear Reactor Materials</td>
<td>O</td>
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<td>3G</td>
<td>M. A. Pouchon, P. J.-P. Spätig, M. Streit</td>
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<td>151-2037-00L</td>
<td>Nuclear Decommissioning of Nuclear Power Plants</td>
<td>O</td>
<td>4</td>
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<td>A. Pautz, H. Ferroukhi, further lecturers</td>
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Abstract

The course deals with the important challenges for materials (structural and fuel) for current and advanced nuclear power plants. Experimental techniques and tools used for working with active materials are discussed in detail. Students will be well acquainted with analytical and modeling methodologies for damage assessment and residual life determination and with the behavior of high burnup fuel.

Objective

The course will highlight the above needs from different points of view. Experimental methods for the control and analysis of nuclear components and materials in operating NPPs will be presented. Advanced analytical and modeling tools will be introduced for parameter characterization and understanding of irradiation damage, creep, environment effects, etc. Insights acquired from recent experimental programs into high burnup fuel behavior under hypothetical accident conditions (RIA, LOCA) will be presented. Materials for advanced future nuclear plants will be discussed.

<table>
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<tr>
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<td>4</td>
<td>3G</td>
<td>A. Manera, T. Lind, D. Paladin</td>
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Abstract

To acquire hands-on experience with the running of large computer codes in relation to the static analysis of nuclear reactor cores and the multi-physics simulation of nuclear power plant (NPP) dynamic behaviour.

Objective

To acquire hands-on experience with the running of large computer codes in relation to the static analysis of nuclear reactor cores and the multi-physics simulation of nuclear power plant (NPP) dynamic behaviour.

Content

- Lattice (assembly) calculations
- Thermal-hydraulic analysis
- Reactor core analysis
- Multi-physics core dynamics calculations
- Best-estimate NPP transient analysis

Prerequisites / notice

Required prior knowledge: Special Topics in Reactor Physics, Nuclear Safety

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-2045-00L</td>
<td>Decommissioning of Nuclear Power Plants</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>A. Pautz, F. Leibundgut, A. Manera</td>
</tr>
</tbody>
</table>

Abstract

Introduction to aspects of Nuclear Power Plant decommissioning including project planning and management, costs and financing, radiological characterization, dismantling/decontamination technologies, safety aspects and radioactive waste management considerations.

Objective

Aim of this course is to provide the students with an overview of the multidisciplinary issues that have to be addressed for the successful decommissioning of NPPs. Students will get exposed to principles of project management, operations management, cost estimations, radiological characterization, technologies relevant to the safe dismantling of NPPs and best-practice in the context of radioactive waste management.

Content

Legal framework, project management and operations methods and tools, cost estimation approaches and methods, nuclear calculations and on-site radiological characterization and inventorying, state-of-the-art technologies for decontamination and dismantling, safety considerations, state-of-the-art practice for radioactive waste treatment, packaging and transport, interface with radioactive waste management and disposal. The course will additionally include student visits to relevant nuclear sites in Switzerland and Germany.

Prerequisites / notice

Prerequisites: Recommended courses: 151-0156-00L Safety of Nuclear Power Plants plus either 151-0163-00L Nuclear Energy Conversion or 151-2015-00L Reactor Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-2005-00L</td>
<td>Elective Project Nuclear Engineering</td>
<td>W</td>
<td>8</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1751 of 2345
The elective project has the purpose to train the students in the solution of specific engineering problems related to nuclear technology. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective
The elective project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

227-0385-10L Biomedical Imaging

Abstract
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

Objective
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

Content
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Prerequisites / notice
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

ECTS
64D

227-0965-00L Micro and Nano-Tomography of Biological Tissues

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Prerequisites / notice
Lecture notes and handouts

Literature
Available online

ECTS
4 credits

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1752 of 2345
b. fulfilling of any additional requirements necessary to
gain admission to the master programme.
c. successful completion of the semester project.
d. completion of minimum 72 ECTS in the categories
"Core Courses" and "Electives" in the Master studies and
completion of 8 ECTS in the "Semester Project"

For the supervision of the Master's Thesis, the following professors can be chosen: H.-M. Prasser (ETHZ), A. Manera (ETHZ), M.Q. Tran (EPFL), A. Pautz (EPFL)

Abstract
Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

Objective
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

Nuclear Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Z</th>
<th>Courses outside the curriculum</th>
<th>W+</th>
<th>Eligible for credits and recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Pharmacoepidemiology and Drug Safety

### Core Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0030-00L</td>
<td>Therapeutic Proteins</td>
<td>O</td>
<td>3</td>
<td>3G</td>
<td>C. Halin Winter, D. Neri</td>
</tr>
</tbody>
</table>

**Abstract**

In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

**Objective**

Students know and understand:
- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins

**Content**

The course consists of two parts:

In a first part, students will complete their training of pharmaceutical immunology (Chapter 13 - 16 Immunobiology VIII textbook). This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.

The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

**Lecture notes**

Handouts to the lectures will be available for downloading under [http://www.pharma.ethz.ch/scripts/index](http://www.pharma.ethz.ch/scripts/index)

**Literature**

- Janeway's Immunobiology, by Kenneth Murphy (9th Edition), Chapters 12-16
- Lecture Handouts
- Paper References provided in the Scripts
- EMEA Dossier for Humira

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0041-00L</td>
<td>Pharmacology and Toxicology III</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>U. Quitterer, M. Arand, Y. Yamauchi</td>
</tr>
</tbody>
</table>

**Abstract**

The course is divided into two parts. The first part provides a detailed understanding of drugs and the pharmacotherapy of infectious diseases and cancer. The second part gives an overview of the field of pharmacoepidemiology and toxicogenomics with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

**Objective**

The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases and cancer. The course also provides an overview of the field of pharmacoepidemiology and toxicogenomics, with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

**Content**

Topics include the pharmacology and pharmaceutical therapy of infectious diseases and cancer. In the field of pharmacoepidemiology and toxicogenomics, the course is focused on genetics, genome-wide association studies, examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacoepidemiology and toxicogenomics for clinical drug development.

**Lecture notes**

A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.

**Literature**

Recommended reading:

- The classic textbook in Pharmacology: Goodman and Gilman’s The Pharmacological Basis of Therapeutics
- Lawrence Brunton, Bjorn Knollman, Randa Hilal-Dandan
  ISBN-10: 1259584739
  or 14th edition (expected Oct. 2022)
  or
  - Klaus Aktories, Ulrich Förstermann, Franz Hofmann, Klaus Starke
  Allgemeine und spezielle Pharmakologie und Toxikologie
  Urban & Fischer (Elsevier, München)

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0050-00L</td>
<td>Pharmacoepidemiology and Drug Safety</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>A. Burden, S. Russmann</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.

**Objective**

Objectives:
- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for the qualitative evaluation of drug safety
- Set up of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

**Content**

- Historical landmarks of drug safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)
- Medication errors, clinical pharmacology / clinical pharmacy
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, ‘Big Data’
- Interactive discussion of many real-life examples for each topic

**Lecture notes**

This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through seminars, case studies in small groups.

Reading material and scripts will be provided for each week.
## Literature

- **Recommended literature**
  - Rothman: Introduction to Epidemiology
  - Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
  - Gigerenzer: Risk Savvy - How to Make Good Decisions

## Literature 535-0546-0L Patents

### Abstract
Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Introduction into intellectual property; prosecution of patent applications; patent information; exploitation and enforcement of patents; peculiarities in pharmaceutics and medicine; social, political and ethical aspects; Trademarks.

### Objective
Basic knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

### Content
1. Introduction into industrial property (patents, trademarks, industrial designs);
2. Prosecution of patent applications (patentability);
3. Patent information (patent publications, databases, searches);
4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement);
5. Peculiarities in pharmaceutics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication);
6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions);
7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma-trademarks.

### Lecture notes
A script is provided in electronic form during the lecture.

### Literature

### Prerequisites / notice
None

## Literature 511-0000-00L Drug Discovery and Development

### Abstract
This course provides an overview over the concepts and processes employed in today's drug discovery and development. It has an introductory character but will also provide more detailed insights employing real life examples. The course combines lectures and interactive elements with active participation of the students.

### Objective
Students
- Understand the drug discovery process and can explain major approaches and relevant technical terms (for details see lecture notes).
- Understand the content and timing of drug development process steps, development phases and decision criteria.
- Understand the concepts underlying drug product development through all the phases from preclinical and clinical development to regulatory submission, approval and market launch.
- Understand the most important differences for drug development and approval between the EU and USA pharma markets with regard to legal and regulatory requirements.

### Content
Course unit comprises weekly lectures covering the early phases of target and drug discovery (535-0910-01 S "From A to Z in Drug Discovery and Development I") with group work in the area of Drug Development (511-0000-00 G). The latter course lasts 2 full days (Days 1 and 2) and comprises both lectures and group work: inter alia an introduction to the entire suite of drug product development processes in the pharmaceutical industry, covering preclinical research and development, clinical development, regulatory processes and market launch.

### Lecture notes
Will be published on "mystudies".

### Literature

### Prerequisites / notice
This course provides the essential basic knowledge required for the industry-specific modules of the spring semester.

#### Safety concept:
https://chab.ethz.ch/studium/bachelor1.html
Scientific Writing and Presenting

Abstract
This introductory class provides an overview of the basic scientific writing techniques and a guideline to presenting scientific data, together with guided exercises and hands-on training. It is devised to accompany the research projects within the curriculum of the MSc in Pharmaceutical Sciences.

Objective
The class enables the participants to prepare their own scientific texts and oral presentations, and critically assess the quality of the presentation of scientific data.

Content
The participants receive an introduction to basic formal aspects of scientific writing and the design of graphical elements. Lectures and topical seminars alternate with practical task for the participants, which will be evaluated in a peer-to-peer setting. Performance feedback is provided by both the teachers and the peers.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Project Management</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
</tr>
</tbody>
</table>

511-0007-00L Scientific Writing and Presenting

Only for Pharmaceutical Sciences MSc.

Abstract
This introductory class provides an overview of the basic scientific writing techniques and a guideline to presenting scientific data, together with guided exercises and hands-on training. It is devised to accompany the research projects within the curriculum of the MSc in Pharmaceutical Sciences.

Objective
The class enables the participants to prepare their own scientific texts and oral presentations, and critically assess the quality of the presentation of scientific data.

Content
The participants receive an introduction to basic formal aspects of scientific writing and the design of graphical elements. Lectures and topical seminars alternate with practical task for the participants, which will be evaluated in a peer-to-peer setting. Performance feedback is provided by both the teachers and the peers.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The course is reserved for students registered in the Master's programme in Pharmacy or in Pharmaceutical Sciences</td>
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</table>

Abstract
The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences. Students work in small groups on a chosen topic, they write a mini-review and present their work on a one day symposium.

Objective
The main objectives of this course are:

- students develop their scientific reflection (Critical Thinking) and working skills by working independently on a relevant pharmaceutical topic
- students gain in-depth knowledge of the topic investigated
- students train their scientific writing and presentation skills
- students train their ability to plan a project and work in a team

Content
The Course Drug Seminar takes place during the first 7 weeks of the 1. Master semester. It is a compulsory course of the MSc Pharmacy curriculum and an elective course in the MSc PharmSciences.

The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences.

During the course, students work in small teams on a topic of their choice and elaborate a written mini-review and an oral presentation. Each team is tutored by a lecturer of the Institute of Pharmaceutical Sciences. The work is mainly based on literature search / review, but may also involve conducting interviews or site visits, if appropriate. The final presentations of all groups will take place in the framework of a dedicated Symposium held in the middle of the semester.

Prerequisites / notice
Only for students of MSc Pharmacy and MSc Pharmaceutical Sciences.

511-1001-00L Biopharmacy (Crash Course)

Only for Pharmaceutical Sciences MSc.

Abstract
This course provides the basic concepts of biopharmacy (ADMET, absorption, distribution, metabolism, excretion, toxicity of drugs) and pharmacokinetics. After an introduction to the fundamental parameters and concepts, the participants will study independently and apply and consolidate their knowledge in tutorials.

Objective
- Knowledge of the ADMET processes and the respective pharmacokinetic parameters.
- Interpretation of pharmacokinetic parameters.
- Analysis of drug plasma concentration-time curves.
- Prediction of pharmacokinetic parameters based on in vitro assays and physicochemical drug properties.
- Knowledge of the effects of physiological factors on the pharmacokinetic parameters and on drug plasma and tissue concentrations.
- Design of dosage regimens, based on pharmacokinetic parameters.
- Prediction of drug-drug interaction potentials based on in vitro assays and pharmacokinetic parameters.
- Introduction to pharmacokinetic profiling of drugs for therapy optimization and for the analysis of the interaction potential.
- Design of dosage regimen. In vitro assays to predict pharmacokinetic parameters.

Content
- Introduction to biopharmacy (ADMET) and pharmacokinetics.
- Definition of the most important pharmacokinetic parameters and their calculation from plasma concentration-time curves.
- Introduction to compartment models, statistical models, physiological models.
- Pharmacokinetic profiling of drugs for therapy optimization and for the analysis of the interaction potential.
- Design of dosage regimens. In vitro assays to predict pharmacokinetic parameters.

Lecture notes
Slides, see documents repository.

Literature
DOI: 10.1002/9783527645763

Prerequisites / notice
Obligatory course if assigned by the Admission committee.

511-1002-00L Pharmaceutical Analytics and Pharmacopeia (Crash Course)

Only for Pharmaceutical Sciences MSc.

Abstract
This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation. After an introduction to the fundamental techniques and concepts, the participants will study independently, apply and consolidate their knowledge in tutorials.
Objective

Students are able to:
summarize the structure of the Ph. Eur.
summarize the most important pharmacopeias and their communalities and differences
discuss the structure of a monograph
explain qualification of instruments and validation of methods
explain and compare most important analytical techniques for pharmaceutical industry

Content

Students gain knowledge in pharmaceutical analytics to fulfill regulatory requirements in pharmaceutical industry based on the pharmacopeia in force. Focus is set on method validation, equipment qualification, identification, purity testing and content determination of active pharmaceutical ingredients and excipients.

Lecture notes

Slides, see documents repository

Literature


511-1003-00L Gene Technology (Crash Course) E- 1 credit 1S J. Scheuermann

Obligatory course if assigned by the Admission committee.

Abstract

The course enables the student to understand and apply the general concepts of gene technology, including recombinant DNA technology and its application in genomics, transcriptomics and proteomics. Protein cloning, expression and modifications and bimolecular interactions will be discussed. The concept of display technology and its applications in the field of drug discovery will be presented.

Objective

The students remember and understand:
1. The tools of recombinant DNA technology
2. Next generation sequencing approaches and their relevance for -omics projects
3. Protein cloning, expression, modification/labelling and oligomerization
4. Thermodynamic and kinetic affinity constants in bimolecular reactions
5. Basic structure of the antibody molecule
6. Concepts of antibody phage technology and antibody engineering
7. Construction of antibody-, peptide- or small molecule libraries and affinity-based selection methodologies

Content

I) Genomics:
- recombinant DNA technology
- methods to sequence genomes
- application to human biology
- Transcriptomics / Proteomics

II) Proteins:
- protein cloning and expression
- homo- and heterodimerization
- chemical modifications and radioactive labelling
- detection of bimolecular interactions
- affinity constant and experimental measurement
- kinetic association and dissociation constants

III) Display technology:
- the antibody molecule, CDRs, basics of antibody engineering
- antibody phage display and selection methodologies
- construction of antibody libraries
- other display technologies (peptide display, DNA-encoded chemical libraries)

Lecture notes

slides and script used for the course and literature for reading and discussions will be made available online.

Literature


dedicated articles will be announced

Prerequisites / notice

admission to MSc in Pharmaceutical Sciences

535-0423-00L Drug Delivery and Drug Targeting W 2 credits 1.5V J.-C. Leroux

Abstract

The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective

The students dispose on an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes

Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature


Further references will be provided in the course.
### Taught competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**
- Adaptability and Flexibility: assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Literature

**535-0250-00L**

**Biotransformation of Drugs and Xenobiotics**

<table>
<thead>
<tr>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>S.-D. Krämer</th>
</tr>
</thead>
</table>

**Abstract**
Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

**Objective**
Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

**Content**
Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Toxic reactions of metabolites. Factors which affect the biotransformation.

**Lecture notes**
Biotransformation of drugs and xenobiotics

**Literature**

**535-0015-00L**

**History of Pharmacy**

<table>
<thead>
<tr>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>S. Ruppen</th>
</tr>
</thead>
</table>

**Abstract**
In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs.

**Objective**
After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and medicines and to place them in a temporal context. They can list sources for working on questions from the history of pharmacy and evaluate their advantages and disadvantages. This enables them to confidently describe the importance of pharmacy as an independent, supporting pillar of the health system, the history of which has many interfaces with medicine, science, social and cultural history.

**Content**
The lecture conveys knowledge about the development of the pharmacist profession from ancient times to the present. Some pharmacists who made significant contributions to pharmacy are presented in more detail and their significance for today’s pharmacy is discussed. The social position of pharmacists in society and the legal conditions in different epochs are also discussed. It explains what influence the pharmacists had on the development of the pharmaceuticals, but again the pharmacists on the development of the pharmacists. For this purpose, it is shown how much the meaning, the nature, the type and the composition of pharmaceuticals and the knowledge about them changed over time.

**Lecture notes**
Wird in der ersten Veranstaltung mitgeteilt.

**Prerequisites / notice**
An interest in the history of pharmacy, the pharmacy profession, and medicines is an asset.

**535-0344-00L**

**From Ethnopharmacy to Molecular Pharmacognosy**

<table>
<thead>
<tr>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>B. Frei Haller, A. Lardos</th>
</tr>
</thead>
</table>

**Abstract**
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

**Objective**
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

**Content**
Introduction into ethnopharmacy and related disciplines; definitions of terms, working methods, research projects, bioprospecting. Traditional medicinal plants of different cultures and their role in modern Western medicine (rational application of traditional uses). Historical data as sources for drug research. Today’s “fashion plants.” Empirical, traditional knowledge versus Evidence Based Medicine. The role of biodiversity (CBD, Rio 1992; Nagoya, 2010) and problems associated with drug discovery from natural products. Screening strategies for drug discovery (random screening versus screening based on cultural, ecological, ethnopharmaceutical, chemotaxonomic criteria). Traditional knowledge in relation to the fight against malaria and its implementation in research, product development and development cooperation. Introduction to and selected examples of herbal drugs and poisons, mode of action, and their ethnopharmaceutical importance. Critical analysis of bioprospecting as a drug discovery strategy.

**Lecture notes**
Handouts will be provided.

**Literature**

**Prerequisites / notice**
Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.
Vitamins in Health and Disease

Aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.
Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested.

A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period. The lecture ‘Vitamins in Health and Disease’ will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

### 535-0360-00L Evidence Based Phytotherapy

**Abstract**
Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed.

**Objective**
Students should learn the importance of rational (= evidence-based) pharmacotherapy with herbal extracts.

They should know the most important aspects of herbal medicinal products:
- o How are interesting development candidates identified. What are the strategies?
- o What are the regulatory requirements (Traditional use, well-established use, new herbal entities)?
- o Efficacy determination (animal/human studies, biomarkers)
- o Pharmacokinetics
- o Safety (toxicity, adverse effects, interactions)
- o Pharmaceutical quality
- o Origin of the plant raw material (wild collections, cultivation)
- o Ensuring consistent quality
- o Which extraction methods?

The following important plants and products will be presented and critically discussed as examples (see program below)

1) 21.09.2: Introduction :
Quality of medicinal plant, finished products, monographs (Commission E, ESCOP, HMPC), differences in terms of registration status and requirements: traditional use, well established use and new herbal entities; extracts, quality medicinal drugs.

2) 28.9.2022: Phases of clinical development, basic concepts of evidence-based medicine. Hypericum perforatum

3) 05.10.22: Phytotherapy for functional intestinal disorders; Harpagophytum spp.

4) 12.10.2022: Silybum marianum; Pelargonium spp.

5) 19.10.2022: Lavandula oleum; Echinacea spp.

6) 26.10.2022: Cimicifuga racemosa; Cannabis sativa

7) 02.11.2022: Exam (Multiple Choice).

The selection of plants may be subject to change. Die Skripten werden vor den jeweiligen Vorlesungen per Email an die Teilnehmer/Innen versandt.

### 535-0137-00L Clinical Chemistry II

**Abstract**
Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Objective**
Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interprete selected tests.

**Content**
Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Lecture notes**
Documentation will be available before the lectures electronically.

**Literature**
- Jürgen Hallbach, Klinische Chemie und Hämatologie für den Einstieg, Thieme Verlag
- Harald Renz, Praktische Labordiagnostik, de Gruyter Verlag
- Walter Guder, Das Laborbuch für Klinik und Praxis, Elsevier Verlag
- Lothar Thomas, Labor und Diagnostik, TH Books
- William Marshall, Clinical Chemistry, Mosby Ltd.
- Alan H.B. Wu, Tietz, Clinical Guide to Laboratory Tests, Saunders

**Prerequisites / notice**
Requirement: basic knowledge in clinical chemistry and laboratory diagnostics.

### 535-0022-00L Computer-Assisted Drug Design

**Abstract**
The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.), and structure-based virtual screening (docking, physics-based models). A small team discussion will be organized to discuss recent research findings. A seminar talk is to be given presenting the molecular design strategy chosen and the results obtained during the course.

Additional selected literature will be provided during the lecture. The lecture is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

### Research Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>511-0003-00L</td>
<td>Practical Methods in Pharmaceutical Sciences</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

### Electives II

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>511-0004-00L</td>
<td>Research Project</td>
<td>W</td>
<td>15 credits</td>
<td>39A</td>
<td>Lecturers</td>
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</tbody>
</table>

The course offers the possibility for people with and without computational and or laboratory background to get an introduction into computer-assisted drug design, as well as practical training in a modern chemical laboratory. Using various software suites, the participants will computationally create and screen a virtual compound library for potential active small molecules. The process will involve an introduction to screening a virtual compound library, synthesizing candidate inhibitors, and biophysical testing against a pharmacologically important drug target.

Additional selected literature will be provided during the lecture. The lecture is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

The course is open for master and graduate students to get an introduction into hands-on computer-assisted drug design. The class includes an introduction to computer-based screening of a virtual compound library, subsequent synthesis of candidate ligands, and biochemically testing for activity on pharmacologically important drug targets.

Participants become familiar with state-of-the-art methodologies in a real-life computer-aided medicinal chemistry project. Participants work as small teams, perform literature research and discuss recent research findings. A seminar talk is to be given presenting the molecular design strategy chosen and the results obtained during the course.

The class is organized as a two-week block course. The number of participants is limited.

The course takes place outside universities, the main locations being: pharmaceutical industry, consultancy, health and regulatory authorities and hospitals. Students experience the professional handling of questions in the field of pharmaceutical sciences through their own practical activities.

**Research Project**

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</table>

The course is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

The research group is chosen by the student.

The lecture is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

The course is open for master and graduate students to get an introduction into hands-on computer-assisted drug design. The class includes an introduction to computer-based screening of a virtual compound library, subsequent synthesis of candidate ligands, and biochemically testing for activity on pharmacologically important drug targets.

Participants become familiar with state-of-the-art methodologies in a real-life computer-aided medicinal chemistry project. Participants work as small teams, perform literature research and discuss recent research findings. A seminar talk is to be given presenting the molecular design strategy chosen and the results obtained during the course.

The course offers the possibility for people with and without computational and or laboratory background to get an introduction into computer-assisted drug design, as well as practical training in a modern chemical laboratory. Using various software suites, the participants will computationally create and screen a virtual compound library for potential active small molecules. The process will involve an introduction to screening a virtual compound library, synthesizing candidate inhibitors, and biophysical testing against a pharmacologically important drug target.

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<td>Research Project</td>
<td>W</td>
<td>15 credits</td>
<td>39A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

The course is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

The research group is chosen by the student.

The course takes place outside universities, the main locations being: pharmaceutical industry, consultancy, health and regulatory authorities and hospitals. Students experience the professional handling of questions in the field of pharmaceutical sciences through their own practical activities.

**Research Project**

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</thead>
<tbody>
<tr>
<td>511-0004-00L</td>
<td>Research Project</td>
<td>W</td>
<td>15 credits</td>
<td>39A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

The course is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

The research group is chosen by the student.

The course takes place outside universities, the main locations being: pharmaceutical industry, consultancy, health and regulatory authorities and hospitals. Students experience the professional handling of questions in the field of pharmaceutical sciences through their own practical activities.
In an internship the students experience the professional handling of questions in the field of pharmaceutical sciences through their own practical activities and be able to implement the knowledge gained, by

• analysing problems in their complexity and developing solutions in a conceptual way,
• experiencing the aspects of an everyday working environment,
• acquiring key skills,
• establishing contacts for prospective careers.

Work experience outside of university, duration of at least 12 weeks.

An Internship agreement is set up between the student, the company and a member of the teaching staff of the Institute of Pharmaceutical Sciences.

At the end of the internship, the student draws up a formal report.

### Master’s Thesis

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>511-0002-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>4D</td>
<td>Lecturers</td>
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</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is usually carried out in a subject area of Pharmaceutical Sciences as chosen by the student.

### Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

see Science in Perspective: Language Courses ETH/UZH

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>535-0421-AAL</td>
<td>Galenic Pharmacy I+II</td>
<td>E</td>
<td>4 credits</td>
<td>7R</td>
<td>J.-C. Leroux</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharmaceutical excipients, materials, containers, liquid, solid and semi-solid dosage forms, their production, function, quality and application.

Knowledge of the most important pharmaceutical excipients, materials, containers, liquid, solid and semi-solid dosage forms, of their production, function, quality, stability and application. Comprehension of the molecular interactions in solid state, solution and colloidal systems.


Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Pharmacology and Toxicology I+II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course is a condition for admission to the Pharmaceutical Sciences Master. By self-directed learning, students acquire knowledge about basic principles in pharmacology and toxicology, mechanisms of drug action and clinical uses of important classes of drugs.

Objective
After the successful completion of this course, students have gained knowledge about basic principles in pharmacology and toxicology, mechanisms of drug action and clinical uses of important classes of drugs.

Content
Contents of this course are defined by the textbook "Basic and Clinical Pharmacology" by Bertram Katzung.

The following sections are exam-relevant.
- Section-I Basic Principles, No. 2,3,4.
- Section-II, Autonomic Drugs, No. 6,7,8,9,10.
- Section-III Cardiovascular-Renal Drugs, No. 11,12,13,15.
- Section-IV Drugs with Important Actions on Smooth Muscle, No. 16,20.
- Section-V Drugs that Act in the Central Nervous System, No. 21,22,24,26,27,28,29,30,31.
- Section-VI Drugs Used to Treat Diseases of the Blood, Inflammation and Gout, No. 34,35,36.
- Section-VII Endocrine Drugs, No. 39,41.

Lecture notes
Course contents are defined by the textbook "Basic and Clinical Pharmacology" by Bertram Katzung and Anthony Trevor. Exam-relevant sections of this book are listed above in the contents section.

Literature
Basic and Clinical Pharmacology
Bertram Katzung, Todd W. Vanderah
15th edition (Dec. 2020)
McGraw-Hill Education
ISBN-10: 126045231X
Pharmaceutical Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Notes</th>
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</thead>
<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>W+  Eligible for credits and recommended</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>W   Eligible for credits</td>
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<td></td>
<td></td>
<td>E-  Recommended, not eligible for credits</td>
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</table>

Key for Hours

<table>
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<tr>
<th>Key</th>
<th>Type</th>
<th>Notes</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P    practical/laboratory course</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A    independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D    diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R    revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

**Special students and auditors need special permission from the lecturers.**
## Personal Competencies
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

## Taught competencies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-1001-01L</td>
<td>General Chemistry (for Biol./Pharm.Sc.)</td>
<td>O</td>
<td>4 credits</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
</tbody>
</table>
| Abstract | The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.  
| Objective | The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.  
|               | Weiterführende Literatur:  
|               | Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch) |
| Taught competencies | Concepts and Theories | assessed |
|                          | Techniques and Technologies | assessed |
|                          | Analytical Competencies | assessed |
|                          | Decision-making | assessed |
|                          | Media and Digital Technologies | not assessed |
|                          | Problem-solving | assessed |
|                          | Project Management | not assessed |
| Social Competencies | Communication | not assessed |
|                          | Cooperation and Teamwork | not assessed |
|                          | Customer Orientation | not assessed |
|                          | Leadership and Responsibility | not assessed |
|                          | Self-presentation and Social Influence | not assessed |
|                          | Sensitivity to Diversity | not assessed |
|                          | Negotiation | not assessed |
| Personal Competencies | Adaptability and Flexibility | not assessed |
|                          | Creative Thinking | assessed |
|                          | Critical Thinking | assessed |
|                          | Integrity and Work Ethics | not assessed |
|                          | Self-awareness and Self-reflection | not assessed |
|                          | Self-direction and Self-management | assessed |
| 529-1011-00L | Organic Chemistry I (for Biol./Pharm.Sc./HST)  | O    | 4 credits | 4G | C. Thilgen |
| Abstract | Fundamentals of Organic Chemistry: molecular structure. Bonding and functional groups; nomenclature; resonance and aromaticity; stereochemistry; conformation; bond strength; organic acids and bases; basic reaction thermodynamics and kinetics; reactive intermediates: carbanions, carbenium ions and radicals.  
| Objective | Understanding the basic concepts and definitions of organic chemistry. Knowledge of the functional groups and classes of compounds that are important in biological systems. Foundations for the understanding of the relationship between structure and reactivity.  
|                          | · Organic Chemistry I as a Second Language – Translating the basic concepts (Taschenbuch mit Übungen; 400 Seiten).  
| Prerequisites / notice | The course consists of lectures (36 hours) and problem-solving lessons (20 hours, groups of ca. 25 people). In addition, online exercises are available in the e-learning environment Moodle (Course OC I).  
| Taught competencies | Concepts and Theories | assessed |
|                          | Analytical Competencies | assessed |
| Social Competencies | Communication | not assessed |
|                          | Cooperation and Teamwork | not assessed |
|                          | Customer Orientation | not assessed |
| Personal Competencies | Adaptable and Flexible | not assessed |
|                          | Critical Thinking | not assessed |
|                          | Integrity and Work Ethics | not assessed |
|                          | Self-awareness and Self-reflection | not assessed |
|                          | Self-direction and Self-management | not assessed |
Biochemistry of Cells
R. Glockshuber, K. Locher, J. Piel

Abstract
The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

Objective
Introduction to biochemistry, molecular biology and evolutionary principles

Content
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

Lecture notes
The newly conceived lecture is supported by scripts.

Literature

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences, which are focused on within the first two years as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

Objective
First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

Content
Introduction to Pharmaceutical Sciences by selected milestones of research and development. Overview on research activities at the Institute of Pharmaceutical Sciences that is focussed on drug delivery and development (from concepts to prototypes). Sensitization for communication skills and information management. Demonstration of job opportunities in community pharmacies, in the hospital, in industry, and in the public sector by experts in the different fields.

Lecture notes
Handouts for individual lectures.

Prerequisites / notice
Interactive teaching

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>401-0291-00L</td>
<td>Mathematics I</td>
<td>O</td>
<td>6 credits</td>
<td>4V+2U</td>
<td>E. W. Farkas</td>
</tr>
</tbody>
</table>

Abstract
Mathematics I is an introduction to one- and multidimensional calculus and linear algebra emphasizing on applications.

Objective
Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences.
Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems.
## Eindimensionale diskrete Entwicklungen ##
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsraten
- Folgen und Grenzwerte

## Funktionen in einer Variablen ##
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

## Differentialrechnung (l) ##
- Veränderungsrate-geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

## Integralrechnung (l) ##
- Stammfunktionen
- Integrationstechniken

## Gewöhnliche Differentialgleichungen (l) ##
- Qualitative Beschreibung an Beispielen:
  - Beschränkt, Logistisch, Gompertz
  - Stationäre Lösungen
  - Lineare DGL 1. Ordnung
  - Trennung der Variablen

## Lineare Algebra ##
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

Lecture notes
In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:
* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature
Siehe auch Lernmaterial > Literatur

**L. Papula**
Mathematik für Ingenieure und Naturwissenschaftler, 2 Bände; Springer Verlag Vieweg.
Via ETHZ-Bibliothek:

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände:
Einführung in die Analysis, Einführung in die Lineare Algebra;
Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF
auch als [pdf](https://people.math.ethz.ch/~blatter/linalg.pdf)

402-0073-00L Physics I

Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics and elements of quantum mechanics.

Objective
Students know and understand the basic ideas of the scientific description of nature. They understand the fundamental concepts and laws of mechanics and they are able to apply them in practical problems. They know the concepts of quantization and quantum numbers.

Content
1. Description of Motion
2. The laws of Newton
3. Work and energy
4. Collision problems
5. Wave properties of particles
6. The atomic structure of matter

Lecture notes
T. Ihn: Physics for Students in Biology and Pharmaceutical Sciences (unpublished lecture notes)
The lecture contains elements of:


Feynman, Leighton, Sands, "The Feynman Lectures on Physics", Volume I (http://www.feynmanlectures.caltech.edu/)

Taught competencies

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed, Problem-solving assessed
- Social Competencies: Cooperation and Teamwork not assessed
- Personal Competencies: Sensitivity to Diversity not assessed, Self-awareness and Self-reflection not assessed, Self-direction and Self-management not assessed

Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0667-00L</td>
<td>Communication and Social Competences</td>
<td>O</td>
<td>1 credit</td>
<td>1V</td>
<td>to be announced</td>
</tr>
</tbody>
</table>

Abstract

Introduction in basic skills for increasing the effectiveness and efficiency of students daily work.

Objective

1) know tools to "study in a paperless way"; have tried out these tools and made their own conscious choice of useful tools.
2) know tools to work efficiently and goal-oriented in teams.
3) can approach problems methodically correct; know important problem-solving techniques.
4) are able to handle scientific texts and sources correctly; know how to write scientific papers.
5) know how to avoid social problems in working teams and how to solve them when they exist.

Content

- Braun Walter, Die (Psycho-) Logik des Entscheidens, Fallstricke, Strategien und Techniken im Umgang mit schwierigen Situationen, Huber, 2010
- Stadelwieser Jürg, Kommunikation als Schlüssel zum Erfolg, Tobler, 2000 (vergriffen/Bibliothek).

Laboratory Course General Chemistry (for Biology and Pharmacy)

Abstract

Introduction to the practical work in a chemistry laboratory. The most important manipulations and techniques are treated, as well as the most fundamental chemical reaction types.

Objective

- Knowledge of the basic chemical laboratory methods
- Basic knowledge of the scientific approach in experimenting
- Observation and interpretation of chemical processes
- Keeping of a reliable laboratory journal

Content

- Simple chemical working techniques/methods
- Separation techniques
- Physical measurements: mass, volume, pH
- Ionic solids (salts)
- Acid/base chemistry, buffers
- Redox reactions
- Metal complexes
- Titrations methods and quantitative spectrometry
- Introduction to qualitative analysis

Lecture notes

Course manual in German (is handed out to the students at the begin of the lessons)
Language: German, English upon request

Literature


is a suitable textbook.

Prerequisites / notice

This practical course causes costs for materials and chemicals. The costs are charged to the students at the end of semester.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Second Year Courses

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0852-00L</td>
<td>Foundations of Computer Science</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>L. E. Fässler, M. Dahinden</td>
</tr>
</tbody>
</table>

Abstract

Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects.

The following topics are covered: modeling and simulations, introduction to programming, introduction matrices, managing data with lists and tables and with relational databases, universal methods for algorithm design.
The students learn to:
- understand the role of computer science in science,
- to control computer and automate processes of problem solving by programming,
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

### Content

1. The role of computer science in science
2. Introduction to Programming with Python
3. Modeling and simulations
4. Data management with lists and tables
5. Data management with a relational database
6. Introduction to Matrices

### Lecture notes

All materials for the lecture are available at www.gdi.ethz.ch

### Literature


### Prerequisites / notice

This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

### Taught competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Adaptability and Flexibility</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
<th>Self-awareness and Self-reflection</th>
<th>Self-direction and Self-management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
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<td>not assessed</td>
<td>not assessed</td>
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<td>not assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>assessed</td>
<td>not assessed</td>
<td>not assessed</td>
<td>not assessed</td>
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<td>not assessed</td>
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</tr>
</tbody>
</table>

### Objective

1. The role of computer science in science
2. Introduction to Programming with Python
3. Modeling and simulations
4. Data management with lists and tables
5. Data management with a relational database
This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation by Ph. Eur and Ph. Helv. This course will be conducted in English. Requirements: 1st year, scientific part. Part of the course is read and checked in English.

**535-0225-00L Pharmaceutical Analytics I**

**Abstract**
Summarize the structure of the Ph. Eur.
Summarize the most important pharmacopoeias and their commonalities and differences (USP, JP, Ph. Eur., Ph. Helv.)
Discuss the structure of a monograph
Explain qualification of instruments and validation of methods
Explain and compare most important analytical techniques for pharmacies and pharmaceutical industry

**Content**
Knowledge in pharmaceutical analytics to fulfill regulatory requirements in pharmaceutical industry based on the pharmacopeia in force.
Focus is set on method validation, equipment qualification, identification of functional groups and content determination of active pharmaceutical ingredients and excipients.

**Lecture notes**
The slides of the lectures will be provided.

**Literature**
Instrumentelle Analytik; G. Rücker, M. Neugebauer, G.G. Willems; Deutscher Apotheker Verlag, Stuttgart
Arzneistoffanalyse; H. J. Roth, K. Eger, R. Troschütz; Deutscher Apotheker Verlag, Stuttgart
Introduction to Pharmaceutical Chemical Analysis; S.H. Hansen, S. Pedersen-Bjergaard, K. Rasmussen; Wiley & Sons

**Prerequisites / notice**
Requirements for the practical course Pharmaceutical Analytics:
SR 2013: 6 credits Analytics/Pharmaceutical Analytics or 36 credits of compulsory lectures 2nd year
SR 2020: 7 credits Pharmazeutische Analytik I und II or 36 credits of compulsory lectures 2nd year

### Laboratory Courses

#### Third Year Courses

#### Core Courses

**535-0230-00L Medicinal Chemistry I**

**Abstract**
The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

**Objective**
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

**Content**
Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions.

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1770 of 2345
Galenical Pharmacy I

Prerequisites / notice
Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.
Attendance of Medicinal Chemistry II in the spring semester.

Abstract
Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharm. excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality and application. Comprehension of molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.

Objective
Knowledge of the most important pharmaceutical excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality, stability and application. Comprehension of the molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in disperse dosage forms.

Content
Introduction and overview of important fundamentals, principles and technologies for the development and manufacturing of dosage forms and drug delivery systems. Overview of the most important pharmaceutical excipients and polymers, their structure, properties and processing; importance of materials properties for containers, Pharmaceutical solvents, fundamentals of solubility and solubilization of drugs. Water treatment processes, sterilization techniques and quality requirements of pharmaceutical water. Parenteral dosage forms and liquid ophthalmics. Surfactants, micelle formation and colloidal systems. Liquid suspensions and emulsions. Stabilization measures in dosage forms.

Literature
Objective

Students
• Are able to analyse, present and discuss common case studies from the pharmacist's practice, based on their basic knowledge in pharmacology.
• deepen their knowledge of therapeutic substance classes and therapy guidelines.
• are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to undesirable other effects and interactions).
• are able to compare different drugs and derive their therapy-relevant characteristics.

Content

Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:
• Indication
• Dosage Form
• Adverse Drug Reactions
• Interactions
• Contraindications

Lecture notes

Is made available via Moodle.

Literature

As stated in the cases.

Prerequisites / notice

The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and discussed in plenary.

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
Self-presentation and Social Influence

Personal Competencies
Critical Thinking

Gene Technology

Abstract
The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

Objective
The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

Content

I) Genomics and transcriptomics
Methods and Techniques:
• Recombinant DNA technology
• Next generation sequencing methods, sequencing of genomes
• CRISPR technology
Application to human biology:
• Functional genomics/transcriptomics
• Principles of cancer, genetic diseases
• Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

II) Proteomics
Methods and Techniques:
• Protein cloning and expression
• The antibody molecule
• Measurement and determination of biomolecular interactions
• Protein characterization and engineering
• Modifications and radioactive labelling
Application to human biology:
• Protein therapeutics
• Proteomic approaches for identification of novel disease-related targets and biomarkers

III) Drug discovery: Protein-based libraries
• Immune repertoire mining
• Display and selection technologies
  1. antibody phage display
  2. other polypeptide display technologies
  3. small-molecules display: DNA-encoded chemical libraries

Lecture notes
The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

Pharmaceutical Immunology

Abstract
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Objective
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Content
Chapters 1 - 11 of the Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition; Garland).
Abstract
Thorough knowledge of major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

Objective
Thorough knowledge of all major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

Content
Basics and principles of clinical microbiology:
- host-pathogen interaction
- symptoms and diagnosis of major bacterial pathogens
- therapeutic regimens commonly used against bacterial disease
- major aspects of medical mycology, virology and parasitology
- epidemiology

Literature
- Madigan M.T. et al., Brock Mikrobiologie, Pearson, 14. aktualisierte Auflage 2015

Prerequisites / notice
Basic knowledge of biochemistry, general microbiology, immunology

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Abstract
Molecular imaging in drug development
Radiopharmaceutical syntheses
Knowledge of the physical principles of radioactivity
Structure and function of radiopharmaceuticals
Examples of application in diagnosis and therapy in humans
Targeted radionuclide therapy

Objective
- The students know and are able to describe the different imaging procedures in medicine, especially PET and SPET.
- At the end of the lecture, the students are able to explain and describe the physical basics in connection with radioactivity and the different types of radioactive radiation that are relevant in radiopharmacy and nuclear medicine.
- The students know how radionuclides can be produced and extracted.
- The students can describe the structure and function of radiopharmaceuticals and are able to develop strategies for the design of new radiopharmaceuticals.
- The students know selected examples of clinically relevant radiopharmaceuticals and can explain the structure and mechanism of action.
- The students can discuss and apply the principles of internal dosimetry of systemically applied radiopharmaceuticals using selected examples.

Content
Introduction to molecular imaging,
Radioactive decay, radiation and radionuclides relevant in nuclear medicine.
Radionuclide generators
Radiopharmaceutical synthesis strategies
Heart, brain and tumour diagnostics with radiopharmaceuticals
Kinetic modelling with radiopharmaceuticals
Tumour therapy with radiopharmaceuticals
Dosimetry of radiopharmaceuticals
Practical aspect of nuclear medicine and radiopharmacy

Literature
- Book Title: Fundamentals of Nuclear Pharmacy Authors Gopal B. Saha
  DOI https://doi.org/10.1007/978-3-319-57580-3.
- Book Title: Radiopharmaceuticals Book Subtitle A Guide to PET/CT and PET/MRI Editors Ferdinando Calabria, Orazio Schillaci
  DOI https://doi.org/10.1007/978-3-030-27779-6.
- Book Title: Radiopharmaceutical Chemistry Editors Jason S. Lewis Albert D. Windhorst, Brian M. Zeglis
  DOI https://doi.org/10.1007/978-3-319-98947-1.

Prerequisites / notice
Basic knowledge in physics and chemistry

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Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed
This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

**Objective**
The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

**Content**
Topics include disease-relevant macroscopic, microscopic, pathobiochemical and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicity, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

**Lecture notes**
A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

**Literature**
Recommended reading:

Urban & Fischer (Elsevier, München)

The classic textbook in Pharmacology;

Goodman and Gilman’s The Pharmacological Basis of Therapeutics
Laurence Brunton, Bjorn Knoillman, Randa Hilal-Dandan.
ISBN-10: 1259584739

or 14th Edition (expected Dec. 2022)

**Prerequisites / notice**
Voraussetzungen: Abschluss Grundstudium

### Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0239-00L</td>
<td>Practical Course in Medicinal Chemistry</td>
<td></td>
<td>O</td>
<td>3 credits</td>
<td>7P</td>
</tr>
<tr>
<td>535-0166-00L</td>
<td>Medical Microbiology Practical Course</td>
<td></td>
<td>O</td>
<td>1 credit</td>
<td>1G</td>
</tr>
<tr>
<td>535-0219-00L</td>
<td>Laboratory Course in Pharmaceutical Analytics</td>
<td></td>
<td>O</td>
<td>4 credits</td>
<td>7P</td>
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</tbody>
</table>

**Abstract**
The course comprises experiments relating to concepts of medicinal chemistry including statistical processing, fitting of experimental data, computer modeling of protein structures, experimental measurement of affinity constants and kinetic dissociation constants for protein ligands. The chemical stability of a drug will be studied. Basic gene cloning and protein expression will be introduced.

**Objective**
Knowledge of experimental methods in drug discovery and development

**Content**
Characterisation of the biophysical and biological properties of drugs.

**Lecture notes**
Scripts

**Literature**
Original literature

**Prerequisites / notice**
Requirements:
Lecture Medicinal Chemistry I in the same semester or earlier.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0239-00L</td>
<td>Practical Course in Medicinal Chemistry</td>
<td></td>
<td>O</td>
<td>3 credits</td>
<td>7P</td>
</tr>
<tr>
<td>535-0166-00L</td>
<td>Medical Microbiology Practical Course</td>
<td></td>
<td>O</td>
<td>1 credit</td>
<td>1G</td>
</tr>
<tr>
<td>535-0219-00L</td>
<td>Laboratory Course in Pharmaceutical Analytics</td>
<td></td>
<td>O</td>
<td>4 credits</td>
<td>7P</td>
</tr>
</tbody>
</table>

**Abstract**
The course comprises experiments relating to concepts of medicinal chemistry including statistical processing, fitting of experimental data, computer modeling of protein structures, experimental measurement of affinity constants and kinetic dissociation constants for protein ligands. The chemical stability of a drug will be studied. Basic gene cloning and protein expression will be introduced.

**Objective**
Knowledge of experimental methods in drug discovery and development

**Content**
Characterisation of the biophysical and biological properties of drugs.

**Lecture notes**
Scripts

**Literature**
Original literature

**Prerequisites / notice**
Requirements:
Lecture Medicinal Chemistry I in the same semester or earlier.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

### Electives

**Wahlfächer werden aus der Kategorie Kompensationsfächer gewählt.**

### Bachelor Studies (Programme Regulations 2013)


Second Year

Second Year Core Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-0151-00L</td>
<td>Anatomy and Physiology I</td>
<td>O</td>
<td>5 credits</td>
<td>4V</td>
<td>D. P. Wörfel, K. De Bock, L. Slomianka, C. Spengler, M. Willecke</td>
</tr>
</tbody>
</table>

Abstract
Basic knowledge of the anatomy and physiology of tissues, of the embryonal and postnatal development, the sensory organs, the neuro-muscular system, the cardiovascular system and the respiratory system.

Objective
Basic knowledge of human anatomy and physiology and basics of clinical pathophysiology.

Content
The lecture series provides a short overview of human anatomy and physiology

Anatomy and Physiology I (fall term):
Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system

Anatomy and Physiology II (spring term):
digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.

Prerequisites / notice
Requirements: 1st year, scientific part.
Part of the course is read and checked in English.

Laboratory Courses 2nd Year

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0229-00L</td>
<td>Practical Course Organic Chemistry (for Students of Biology and Pharmaceutical Sciences)</td>
<td>O</td>
<td>8 credits</td>
<td>12P</td>
<td>C. Thilgen, Y. Yamakoshi</td>
</tr>
</tbody>
</table>

Abstract
Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography)

Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses).

Objective
Learn to take accurate notes of the experiments and to write reports.

Content
Learn to take accurate notes of the experiments and to write reports.

Prerequisites / notice
As a prerequisite, all participants need to pass the "Safety Test HCI Chemie_V2 English" (see https://moodle-app2.let.ethz.ch). A printout of the certificate generated by the system needs to be presented to the teaching assistants prior to starting lab work.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Third Year

Third Year Core Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0230-00L</td>
<td>Medicinal Chemistry I</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>J. Hall</td>
</tr>
</tbody>
</table>

Abstract
The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.
Pharmacology and Toxicology I

Assessed

A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.


Prerequisites
Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.

535-0421-00L Galenical Pharmacy I

3 credits

Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharm. excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality and application. Comprehension of molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.

Knowledge of the most important pharmaceutical excipients, materials, containers, liquid and semi-solid dosage forms, of their production, function, quality, stability and application. Comprehension of the molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in disperse dosage forms.

Introduction and overview of important fundamentals, principles and technologies for the development and manufacturing of dosage forms and drug delivery systems. Overview of the most important pharmaceutical excipients and polymers, their structure, properties and processing; importance of materials properties for containers. Pharmaceutical solvents, fundamentals of solubility and solubilization of drugs. Water treatment processes, sterilization techniques and quality requirements of pharmaceutical water. Parenteral dosage forms and liquid ophthalmics. Surfactants, micelle formation and colloidal systems. Liquid suspensions and emulsions. Stabilization measures in dosage forms.


Language: German and English

Prerequisites / notice
Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.

535-0521-00L Pharmacology and Toxicology I

2 credits

3 credits

This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacoekinetics, side effects, toxicology, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

Recommended reading:

Urban & Fischer (Elsevier, München)

The classic textbook in Pharmacology:

Goodman and Gilman`s The Pharmacological Basis of Therapeutics
ISBN-10: 1259584739
or 14th Edition (expected Dec. 2022)
The course places the basic pharmaceutical knowledge acquired so far in an applied therapeutic context and fosters interdisciplinary thinking in pharmaceutical sciences. Common pharmaceutical case studies, as they can occur in the professional everyday life of a pharmacist, are worked out in group works, presented and discussed.

**Objective**

_Students_
- Are able to analyse, present and discuss common case studies from the pharmacist’s practice, based on their basic knowledge in pharmacology.
- deepen their knowledge of therapeutic substance classes and therapy guidelines.
- are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to undesirable other effects and interactions).
- are able to compare different drugs and derive their therapy-relevant characteristics.

**Content**

Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:
- Indication
- Dosage Form
- Adverse Drug Reactions
- Interactions
- Contraindications

**Lecture notes**

Is made available via Moodle.

**Literature**

As stated in the cases.

**Prerequisites / notice**

The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and discussed in plenary.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td></td>
<td>assessed</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Self-presentation and Social Influence</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**535-0523-00L Pharmaceutical Biology**

**Abstract**

The structure and biosynthesis of plant constituents and the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (extract-based herbal medicines; isolated natural products) are discussed. Areas of focus are (a) major biosynthetic pathways for plant-derived natural products, (b) pharmacological effects of herbal extracts, and (c) molecular mechanisms of action.

**Objective**

The understanding of the biosynthesis of plant-derived natural products. Acquisition of fundamental knowledge on the medical applications of important herbal medicines and of isolated natural products (general disease areas, molecular constituents of medicinal plants and herbal medicines in general, molecular constituents responsible for pharmacological activity, possible mechanisms of action, available clinical data to support medical use).

**Content**

The lecture is centered around the discussion of medicinal plants and herbal medicines and their common medical applications. The main areas addressed in the lecture are (a) the structure and biosynthesis of plant constituents (i.e. plant-derived natural products) and (b) the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (herbal medicines based on plant extracts as well as isolated natural products). The basic pathways for the biosynthesis of the most important classes of plant-derived natural products are discussed in detail. Likewise, the molecular basis of the pharmacological effects of medicinal plant extracts (and derived herbal medicines) and their individual constituent components (isolated natural products) is broadly addressed. As part of this discussion the availability of clinical data (or lack thereof) to support specific clinical applications of herbal medicines will be repeatedly highlighted. Potential risks associated with the use of herbal medicines are discussed for selected cases.

Carbohydrates, lipids, terpenes, phenolic compounds, alkaloids, essential oils.

**Lecture notes**

Is provided in parts before each lecture (electronically as pdf) and also available on the Ilias platform via My Studies.

**Literature**

- There is no English translation of the above textbook (or any reasonably equivalent text). Students intending to take the exam for the course and are not sufficiently proficient in German should contact the lecturer before the start of the course.

**Prerequisites / notice**

Requirements: Lecture courses in basic organic chemistry, biochemistry, and biology

**535-0810-00L Gene Technology**

**Abstract**

The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the-art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.
I) Genomics and transcriptomics

Methods and Techniques:
- Recombinant DNA technology
- Next generation sequencing methods, sequencing of genomes
- CRISPR technology

Application to human biology:
- Functional genomics/transcriptomics
- Principles of cancer, genetic diseases
- Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

II) Proteomics

Methods and Techniques:
- Protein cloning and expression
- The antibody molecule
- Measurement and determination of biomolecular interactions
- Protein characterization and engineering
- Modifications and radioactive labelling

Application to human biology:
- Protein therapeutics
- Proteomic approaches for identification of novel disease-related targets and biomarkers

III) Drug discovery: Protein-based libraries

- Immune repertoire mining
- Display and selection technologies
  1. antibody phage display
  2. other polypeptide display technologies
  3. small-molecules display: DNA-encoded chemical libraries

Lecture notes

The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
<th>Decision-making</th>
<th>Problem-solving</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td></td>
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<tr>
<td>Personal Competencies</td>
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</tbody>
</table>

535-0830-00L Pharmaceutical Immunology

Abstract
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Objective
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Content
Chapters 1 - 11 of the Janeway’s ImmunoBiology, by Kenneth Murphy (9th Edition; Garland).

Literature
Janeway’s ImmunoBiology, by Kenneth Murphy (9th Edition).

Paperback [www.garlandscience.com]

535-0210-00L Radiopharmaceutical Chemistry

Abstract
- Molecular imaging in drug development
- Radiopharmaceutical syntheses
- Knowledge of the physical principles of radioactivity
- Structure and function of radiopharmaceuticals
- Examples of application in diagnosis and therapy in humans
- Targeted radionuclide therapy

Objective
- The students know and are able to describe the different imaging procedures in medicine, especially PET and SPET.
- At the end of the lecture, the students are able to explain and describe the physical basics in connection with radioactivity and the different types of radioactive radiation that are relevant in radiopharmacy and nuclear medicine.
- The students know how radionuclides can be produced and extracted.
- The students can describe the structure and function of radiopharmaceuticals and are able to develop strategies for the design of new radiopharmaceuticals.
- The students know selected examples of clinically relevant radiopharmaceuticals and can explain the structure and mechanism of action.
- The students can discuss and apply the principles of internal dosimetry of systemically applied radiopharmaceuticals using selected examples.

Content
Introduction to molecular imaging,
Radioactive decay, radiation and radionuclides relevant in nuclear medicine.
Radionuclide generators
Radiopharmaceutical synthesis strategies
Heart, brain and tumour diagnostics with radiopharmaceuticals
Kinetic modelling with radiopharmaceuticals
Tumour therapy with radiopharmaceuticals
Dosimetry of radiopharmaceuticals
Practical aspect of nuclear medicine and radiopharmacy

Literature
Book Title: Fundamentals of Nuclear Pharmacy Authors Gopal B. Saha
DOI https://doi.org/10.1007/978-3-319-57580-3.

Book Title: Radiopharmaceuticals Book Subtitle A Guide to PET/CT and PET/MRI Editors Ferdinando Calabria, Orazio Schillaci
DOI https://doi.org/10.1007/978-3-030-27779-6.

Book Title Radiopharmaceutical Chemistry Editors Jason S. Lewis Albert D. Windhorst, Brian M. Zeglis
DOI https://doi.org/10.1007/978-3-319-98947-1.

Access via ETH Library
Prerequisites / notice

Prerequisites: basic knowledge in physics and chemistry

Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management
- Sensitivity to Diversity
- Negotiation

Method-specific Competencies
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- Media and Digital Technologies
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- Self-direction and Self-management
- Sensitivity to Diversity
- Negotiation

535-0165-00L Clinical Microbiology

Abstract
Thorough knowledge of major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

Objective
Thorough knowledge of all major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

Content
- Basics and principles of clinical microbiology:
- host-pathogen interaction
- symptoms and diagnosis of major bacterial pathogens
- therapeutic regimens commonly used against bacterial disease
- major aspects of medical mycology, virology and parasitology
- epidemiology

Literature
- Madigan M.T. et al., Brock Mikrobiologie, Pearson, 14. aktualisierte Auflage 2015

Prerequisites / notice

Basic knowledge of biochemistry, general microbiology, immunology

Laboratory Courses 3rd Year
Respective lectures must be attended before/together with the Laboratory Courses. Special schedule for the Laboratory Courses.

Number Title Type ECTS Hours Lecturers
535-0219-00L Laboratory Course in Pharmaceutical Analytics 4 credits 7P C. Steuer

Abstract
Solving analytical problems; Development and interpretation of analytical methods.

Objective
Solving analytical problems; Development and interpretation of analytical methods.

Content
Solving analytical problems. Development and interpretation of analytical methods.

Literature
Skript Pharmazeutische Analytik Praktikum

Prerequisites / notice
SR 2004: 2 credits Analytical Chemistry (529-1041-00), lecture Pharmaceutical Analytics
SR 2013: 6 credits Analytics/Pharmaceutical Analytics or 36 credits of compulsory lectures 2nd year.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

535-0166-00L Medical Microbiology Practical Course

Abstract
Basic Training in Practical Medical Microbiology.

Objective
Supplement to the parallel lecture in Medical Microbiology.

Content
Analysis of simulated clinical specimens using classical methods of Medical Microbiology (microscopy, culture etc.). Main aims are the detection and identification of bacterial, mycobacterial and mycological pathogens as well as microbial susceptibility testing.

Lecture notes
The scriptium (in German) will be distributed at the beginning of the course. It contains all protocols necessary for the practical work

Literature

Prerequisites / notice
Registration for the course until 15 October;
Attendance of the lecture Medicinal Microbiology in the same semester or earlier;
Basic skills in careful laboratory work.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

535-0239-00L Practical Course in Medicinal Chemistry

Abstract
Solving analytical problems; Development and interpretation of analytical methods.

Objective
Solving analytical problems. Development and interpretation of analytical methods.

Content
Solving analytical problems. Development and interpretation of analytical methods.

Literature
Skript Pharmazeutische Analytik Praktikum

Prerequisites / notice
SR 2004: 2 credits Analytical Chemistry (529-1041-00), lecture Pharmaceutical Analytics
SR 2013: 6 credits Analytics/Pharmaceutical Analytics or 36 credits of compulsory lectures 2nd year.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html
The course comprises experiments relating to concepts of medicinal chemistry including statistical processing, fitting of experimental data, computer modeling of protein structures, experimental measurement of affinity constants and kinetic dissociation constants for protein ligands. The chemical stability of a drug will be studied. Basic gene cloning and protein expression will be introduced.

Objective: Knowledge of experimental methods in drug discovery and development

Content: Characterisation of the biophysical and biological properties of drugs.

Prerequisites / notice: Laboratory course in Pharmaceutical Analytics; Lecture Medicinal Chemistry I in the same semester or earlier.

S. Ruppen

Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

K. Berger Büter, A. Lardos

Analytical Competencies
Lecturers

Concepts and Theories

Original literature

Original literature

535-0344-00L From Ethnopharmacy to Molecular Pharmacognosy

Abstract

Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Objective

Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Content

Introduction into ethnopharmacy and related disciplines; definitions of terms, working methods, research projects, bioprospecting. Traditional medicinal plants of different cultures and their role in modern Western medicine (rational application of traditional uses). Historical data as sources for drug research. Today’s “fashion plants.” Empirical, traditional knowledge versus Evidence Based Medicine. The role of biodiversity (CBD, Rio 1992; Nagoya, 2010) and problems associated with drug discovery from natural products. Screening strategies for drug discovery (random screening versus screening based on cultural, ecological, ethnopharmaceutical, chemotaxonomic criteria). Traditional knowledge in relation to the fight against malaria and its implementation in research, product development and development cooperation. Introduction to and selected examples of herbal drugs and poisons, mode of action, and their ethnopharmacological importance. Critical analysis of bioprospecting as a drug discovery strategy.

Lecture notes

Handouts will be provided.

Literature


Prerequisites / notice

Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

535-0360-00L Evidence Based Phytotherapy

Abstract

Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed.

K. Berger Büter

Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html
Students should learn the importance of rational (= evidence-based) pharmacotherapy with herbal extracts. They should know the most important aspects of herbal medicinal products:

- How are interesting development candidates identified? What are the strategies?
- What are the regulatory requirements (Traditional use, well-established use, new herbal entities)?
- Efficacy determination (animal/human studies, biomarkers)
- Pharmacokinetics
- Safety (toxicity, adverse effects, interactions)
- Pharmaceutical quality
- Origin of the plant raw material (wild collections, cultivation)
- Ensuring consistent quality
- Which extraction methods?

The following important plants and products will be presented and critically discussed as examples (see program below):

1) 21.09.2
Introduction:
Quality of medicinal plant, finished products, monographs (Commission E, ESCOP, HMP, differences in terms of registration status and requirements: traditional use, well established use and new herbal entities; extracts, quality medicinal drugs.

2) 28.9.2022:
Phases of clinical development, basic concepts of evidence-based medicine.
Hypericum perforatum

3) 05.10.2022
Phytotherapy for functional intestinal disorders; Harpagophytum spp.

4) 12.10.2022
Silybum marianum; Pelargonium spp.

5) 19.10.2022:
Lavandula oleum; Echinacea spp.

6) 26.10.2022:
Cimicifuga racemosa; Cannabis sativa

7) 02.11.2022:
Exam (Multiple Choice).

The selection of plants may be subject to change.

<table>
<thead>
<tr>
<th>535-0021-00L</th>
<th>Vitamins in Health and Disease</th>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>C. Müller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>The aim of this lecture is a critical examination of the students with the topic of &quot;Vitamins in Health and Disease&quot;. The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with &quot;over-the-counter&quot; products.</td>
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<tr>
<td>Content</td>
<td>Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested. A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period. The lecture 'Vitamins in Health and Disease' will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.</td>
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<tr>
<td>Lecture notes</td>
<td>Hand-outs will be distributed during the lecture (partly in English, partly in German).</td>
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</tr>
<tr>
<td>Literature</td>
<td>Book recommendation: reference books:</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

- Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-9304-8071-8

Prerequisites / notice
Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

<table>
<thead>
<tr>
<th>535-0250-00L</th>
<th>Biotransformation of Drugs and Xenobiotics</th>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>S.-D. Krämer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.</td>
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</tr>
<tr>
<td>Content</td>
<td>Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Toxic reactions of metabolites. Factors which affect the biotransformation.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Biotransformation of drugs and xenobiotics</td>
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</tbody>
</table>


<table>
<thead>
<tr>
<th>535-0310-00L</th>
<th>Glycobiology in Drug Development</th>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>V. I. Otto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.</td>
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</tbody>
</table>

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1781 of 2345
The slides used for the lectures will be provided online.

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

535-0300-00L Molecular Mechanisms of Drug Actions and Targets

Number of participants limited to 24.

Abstract
On average one drug per year is withdrawn from the market. Using selected examples of such drug failures, the course aims at analyzing and discussing the present explanations of drug actions as well as the design and predictive power of animal models and clinical trials. In addition, the ethical, societal, and economical expectations in new drugs shall be reflected and discussed.

Objective
To develop a critical understanding of the relevance and limitations of the current approaches to explaining and anticipating drug effects.

Content
In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the limitations of an extremely reductionist view of atherosclerosis and it's prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success. Torcetrapib is not a single case. In the last 10 years, on average one drug per year was withdrawn from the market due to lack of efficacy, unexpected side effects or toxicity. This clearly shows that the common investigations and the modern understanding of drug actions are often not sufficient to predict the effects a drug will have in large patient populations. These are the topics of the present course. Using three particularly informative examples of drug failures, the problems encountered and the concepts and informative value of preclinical and clinical studies will be analyzed and discussed. Furthermore, the ethical, societal, economical and political expectations in new drugs shall be reflected.

Lecture notes
Lecture slides and literature for reading and discussions will be available online.

Prerequisites / notice
Requirements: basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving

Social Competencies
Communication

Personal Competencies
Creative Thinking
Critical Thinking

535-0423-00L Drug Delivery and Drug Targeting

Abstract
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective
The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature


Further references will be provided in the course.
Table of Contents

Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
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- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

535-0022-00L Computer-Assisted Drug Design

W 1 credit 1V
S. Riniker, G. Landrum

Abstract
The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

Objective
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

Content
The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.), and structure-based virtual screening (docking, physics-based models).

Lecture notes
Script will be available.

Literature
Recommended textbooks:

376-0021-00L Materials and Mechanics in Medicine

W 4 credits 3G
M. Zenobi-Wong, J. G. Snedeker

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
course website on Moodle

Literature

376-1305-00L Development of the Nervous System (University of Zurich)

W 3 credits 2V

University lecturers

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: BIO344

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Objective
On successful completion of the module the student should be able to:
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills
On successful completion of the module the student should be able to:
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
BIO142 Developmental Biology, BIO143 Neurobiology
Abstract
The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.

Content
The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle / OLAT.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Lecture notes
Handouts are deposited online (moodle).

Handouts and references therin.

Literature

(available online via ETH library)

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Prerequisites

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

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Prerequisites

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.
Objective

Recognize chemical structures of the main ingredients and be able to draw them themselves
Understand foods as complex systems and be able to make connections between chemical structures, chemical reactions and their influence on quality.
Recognize chemical reactions of lipid oxidation, Maillard reaction and enzymatic reactions and be able to formulate them themselves.

Content

Descriptive chemistry of food constituents (proteins, lipids, carbohydrates, plant phenolics, flavour compounds).
Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (e.g. lipid oxidation, Maillard reaction, enzymatic browning).
Links to food analysis, food processing, and nutrition.

Topics:
- Lipid oxidation, Maillard reaction, structural proteins/enzymes
- Food as complex systems
- Chemical reactions and reaction mechanisms
- Selected (possibly changing) food chemistry topics (e.g. sweeteners, polysaccharides, from olive to margarine, etc.)

Lecture notes

The lectures Food Chemistry I and Food Chemistry II constitute a unit.

Literature


752-4005-00L Food Microbiology I W 3 credits 2V M. Loessner

Abstract

This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Objective

The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Content

1. History of Food Microbiology
1.1. Short synopsis of foodborne microorganisms
1.2. Spoilage of Foods
1.3. Foodborne Disease
1.4. Food Preservation
1.5. VIP's of Food Microbiology
2. Overview of Microorganisms in Foods
2.1. Origin of foodborne Microorganisms
2.2. Bacteria
2.3. Yeasts
2.4. Molds
3. Microbial Spoilage of Foods
3.1. Intrinsic and Extrinsic Parameters
3.2. Meats, Seafoods, Eggs
3.3. Milk and Milk Products
3.4. Vegetable and Fruit Products
3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
3.6. Drinks and Canned Foods
4. Foodborne Disease
4.1. Significance and transmission of Foodborne pathogens
4.2. Staphylococcus aureus
4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
4.4. Listeria monocytogenes
4.5. Salmonella, Shigella, Escherichia coli
4.6. Vibrio, Yersinia, Campylobacter
4.7. Brucella, Mycobacterium
4.8. Parasites
4.9. Viruses and Bacteriophages
4.10. Mycotoxins
4.11. Bioactive Amines
4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

Recommendations will be given in the first lecture

376-2017-00L Biomechanics of Sports Injuries and Rehabilitation W 3 credits 2V K.-U. Schmitt, J. Goldhahn

Abstract

This lectures introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries.

Objective

Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

Content

This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

Lecture notes

Handouts will be made available.

Literature


Prerequisites / notice

A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loessner, M. Schmelcher, M. Schuppler, E. Wetter Slack

Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1785 of 2345
Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-5103-00L
Functional Microorganisms in Foods

Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.

- Legal and protection issues related to functional foods

- Industrial biotechnology of flavor and taste development

- Safety of food cultures and probiotics

Lecture notes
Copy of the power point slides from lectures will be provided.

Literature
A list of topics for group projects will be supplied, with key references for each topic.

Prerequisites / notice
This lecture requires strong basics in microbiology.

752-5101-00L
Dietary Etiologies of Chronic Disease

Abstract
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Lecture notes
There is no script. Powerpoint presentations will be made available on-line to students.

Literature
To be provided by the individual lecturers, at their discretion.

Prerequisites / notice
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

752-6105-00L
Epidemiology and Prevention

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Taught competencies
Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Method-specific Competencies
- Communication
- Cooperation and Teamwork

Social Competencies
- Creative Thinking
- Critical Thinking

Personal Competencies

752-5001-00L
Food Biotechnology

Abstract
Basic information for understanding biotechnology applied to food processing will be presented. This will include a presentation of the physiology of important productive microorganisms used in food fermentations; microbial and fermentation kinetics, and design and operation of fermentation processes and bioreactors; and application of modern molecular tools for food biotechnology.

Objective
The main goal for this course is to provide students with basic information for understanding biotechnology applied to food processing. For the students, the aim will be:

- To understand the important role of microbial physiology and molecular tools for food biotechnology;
- To understand basic principles of fermentation biotechnology, with particular emphasis on metabolism and kinetics for food applications.

4 credits
3 credits
2V
C. Lacroix, A. Geirnaert, A. Greppi

3V
C. Lacroix, F. Constancias, B. Pugin

B. Pugin
Biotechnology has been defined as any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses. In this course, basic knowledge for understanding biotechnology as applied to food processing will be presented. This course builds on the application of principles learned from other basic courses in the Bachelor program, especially microbiology and microbial metabolism, molecular biology, biochemistry, physics and engineering. Students will learn about the physiology of important productive microorganisms (lactic acid bacteria, bifidobacteria, propionibacteria and fungi) used in food fermentations, closely related to applications in biotechnology. Microbial and fermentation kinetics, and design and operation of fermentations and bioreactors used for both research and industrial scale production of traditional foods and modern food ingredients will be presented. This part will be illustrated by examples of food fermentation processes, representative of specific challenges. Finally, the application of modern molecular tools to food biotechnology will be discussed.

A copy of the power point slides from each lecture will be provided.

A list of references will be given at the beginning of the course for the different topics presented during the course.

**Science in Perspective**

*see Science in Perspective: Type A: Enhancement of Reflection Capability*

*Recommended Science in Perspective (Type B) for D-CHAB*

*see Science in Perspective: Language Courses ETH/UZH*

### Pharmaceutical Sciences Bachelor - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
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<tbody>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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</tbody>
</table>

- Z: Courses outside the curriculum
- Dr: Suitable for doctorate
- O: Compulsory

### Key for Hours

- V: lecture
- G: lecture with exercise
- U: exercise
- S: seminar
- K: colloquium
- P: practical/laboratory course
- A: independent project
- D: diploma thesis
- R: revision course / private study

### ECTS

- European Credit Transfer and Accumulation System
- Suitable for doctorate

Special students and auditors need special permission from the lecturers.
## Pharmacy Master

### Core Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences. Students work in small groups on a chosen topic, they write a mini-review and present their work on a one day symposium.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>The main objectives of this course are:</td>
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<td>- develop their scientific reflection (Critical Thinking) and working skills by working independently on a relevant pharmaceutical topic</td>
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<td>- students gain in-depth knowledge of the topic investigated</td>
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<td>- students train their scientific writing and presentation skills</td>
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<td>- students train their ability to plan a project and work in a team</td>
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<td><strong>Content</strong></td>
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<td>The Course Drug Seminar takes place during the first 7 weeks of the 1. Master semester. It is a compulsory course of the MSc Pharmacy curriculum and an elective course in the MSc PharmSciences.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Only for students of MSc Pharmacy and MSc Pharmaceutical Sciences.</td>
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<tr>
<td>535-0041-00L</td>
<td>Pharmacology and Toxicology III</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>U. Quitterer, M. Arand, Y. Yamauchi</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The course is divided into two parts. The first part provides a detailed understanding of drugs and the pharmacotherapy of infectious diseases and cancer. The second part gives an overview of the field of pharmacogenomics and toxicogenomics with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationships between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases and cancer. The course also provides an overview of the field of pharmacogenomics and toxicogenomics, with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.</td>
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<td><strong>Content</strong></td>
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<td>Topics include the pharmacology and pharmacotherapy of infectious diseases and cancer. In the field of pharmacogenomics and toxicogenomics, the course is focused on genetics, genome-wide association studies, examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development.</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<td>A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.</td>
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<td></td>
<td><strong>Literature</strong></td>
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<td></td>
<td>Recommended reading:</td>
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<tr>
<td>535-0050-00L</td>
<td>Pharmacoepidemiology and Drug Safety</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>A. Burden, S. Russmann</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.</td>
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<td><strong>Objective</strong></td>
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<td>Objectives:</td>
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<td>- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.</td>
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<td>- Perform independently a causality assessment of suspected adverse drug reactions in patients</td>
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<td>- Study designs and biostatistics used for the quantitative evaluation of drug safety</td>
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<td>- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>Historical landmarks of drug safety</td>
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<td></td>
<td>- Pharmacoepidemiology and causality assessment</td>
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<td></td>
<td>- Drug safety in premarketing clinical trials</td>
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<td>- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding</td>
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<td>- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)</td>
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<td>- Medication errors, clinical pharmacology / clinical pharmacy</td>
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<td>- Clinical Decision Support Systems, Interventional Pharmacoepidemiology</td>
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<td>- Pharmacoepidemiological databases, ‘Big Data’</td>
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<td>- Interactive discussion of many real-life examples for each topic</td>
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<td><strong>Lecture notes</strong></td>
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<td>This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through seminars, case studies in small groups. Reading material and scripts will be provided for each week.</td>
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</table>
535-0030-00L  Therapeutic Proteins  O  3 credits  3G  C. Halin Winter, D. Neri

Abstract: In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of therapeutic product quality management.

Objective: Students know and understand:
- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins

Content: The course consists of two parts:
- The first part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.
- The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

Literature:
- Jürgen Hallbach, Grundlagen der Chiropraktischen Medizin und Physiotherapie.
- Urologie
- Rheumatologie
- Pneumologie
- Otorhinolaryngologie
- Ophthalmologie
- Neurologie
- Kardiologie
- Infektiologie
- Gastroenterologie
- Endokrinologie und Diabetes
- Angiologie und Hämatologie
- Dermatologie
- Infektiologie
- Kardiole
- Neurologie
- Ophthalmologie
- Otohriinlaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Grundlagen der Chiropraktischen Medizin und Physiotherapie.

Lecture notes:
- Provided via myStudies.
- As stated in the lecture notes.
Biotransformation of Drugs and Xenobiotics

Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics.

Concepts and Theories

Adaptability and Flexibility

Methods:

Drug Delivery and Drug Targeting

The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

The course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

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Introduction into intellectual property; prosecution of patent applications; patent information; exploitation and enforcement of patents; peculiarities in pharmaceutics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication).

The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics.

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The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

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Further references will be provided in the course.
In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs. W

Handouts will be provided.

Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.


An interest in the history of pharmacy, the pharmacy profession, and medicines is an asset.

None

Table: Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Taught</th>
<th>Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
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<td></td>
</tr>
<tr>
<td>Techniques and Technologies</td>
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<td></td>
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<tr>
<td>Method-specific Competencies</td>
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<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Social Competencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
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<td></td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Negotiation</td>
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<td></td>
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<tr>
<td>Personal Competencies</td>
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<td></td>
</tr>
<tr>
<td>Adaptability and Flexibility</td>
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<td></td>
</tr>
<tr>
<td>Creative Thinking</td>
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<td></td>
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<tr>
<td>Critical Thinking</td>
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</tr>
<tr>
<td>Integrity and Work Ethics</td>
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<td></td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
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<td></td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
<td></td>
</tr>
</tbody>
</table>

535-0015-00L History of Pharmacy W 1 credit 1V S. Ruppen

Abstract
In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs.

Objective
After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and medicines and to place them in a temporal context. They can list sources for working on questions from the history of pharmacy and evaluate their advantages and disadvantages. This enables them to confidently describe the importance of pharmacy as an independent, supporting pillar of the health system, the history of which has many interfaces with medicine, science, social and cultural history.

Content
The lecture conveys knowledge about the development of the pharmacist profession from ancient times to the present. Some pharmacists who made significant contributions to pharmacy are presented in more detail and their significance for today’s pharmacy is discussed. The social position of pharmacists in society and the legal conditions in different epochs are also discussed. It explains what influence the pharmacists had on the development of the pharmaceuticals, but again the pharmaceuticals on the development of the pharmacists. For this purpose, it is shown how much the meaning, the nature, the type and the composition of pharmaceuticals and the knowledge about them changed over time.

Literature

Prerequisites / notice
None

535-0344-00L From Ethnopharmacy to Molecular Pharmacognosy W 1 credit 1V B. Frei Haller, A. Lardos

Abstract
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Objective
Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Content
Introduction into ethnopharmacy and related disciplines; definitions of terms, working methods, research projects, bioprospecting. Traditional medicinal plants of different cultures and their role in modern Western medicine (rational application of traditional uses). Historical data as sources for drug research. Today’s “fashion plants.” Empirical, traditional knowledge versus Evidence Based Medicine. The role of biodiversity (CBD, Rio 1992; Nagoya, 2010) and problems associated with drug discovery from natural products. Screening strategies for drug discovery (random screening versus screening based on cultural, ecological, ethnopharmaceutical, chemotaxonomic criteria). Traditional knowledge in relation to the fight against malaria and its implementation in research, product development and development cooperation. Introduction to and selected examples of herbal drugs and poisons, mode of action, and their ethnopharmacological importance. Critical analysis of bioprospecting as a drug discovery strategy.

Literature

Prerequisites / notice

Prerequisites / notice
None
Communication

Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Molecular Mechanisms of Drug Actions and Targets

Number of participants limited to 24.

Abstract
On average one drug per year is withdrawn from the market. Using selected examples of such drug failures, the course aims at analyzing and discussing the present explorations of drug actions as well as the design and predictive power of animal models and clinical trials. In addition, the ethical, societal, and economical expectations in new drugs shall be reflected and discussed.

Objective
To develop a critical understanding of the relevance and limitations of the current approaches to explaining and anticipating drug effects. To critically appraise the ethical, societal, economical and political expectations in the development of new drugs.

Content
In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the limitations of an extremely reductionist view of atherosclerosis and it's prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success. Torcetrapib is not a single case. In the last 10 years, on average one drug per year was withdrawn from the market due to lack of efficacy, unexpected side effects or toxicity. This clearly shows that the common investigations and the modern understanding of drug actions are often not sufficient to predict the effects a drug will have in large patient populations.

These are the topics of the present course. Using three particularly informative examples of drug failures, the problems encountered and the concepts and informative value of preclinical and clinical studies will be analyzed and discussed. Furthermore, the ethical, societal, economical and political expectations in new drugs shall be reflected.

Lecture notes
Lecture slides and literature for reading and discussions will be available online.

Prerequisites / notice
Lecture slides and literature for reading and discussions will be available online.

Vitamins in Health and Disease

Abstract
Vitamins are essential organic compounds that cannot be synthesized by an organism and hence, thy have to be acquired from the diet. This lecture will give an overview about the application of vitamins in health and disease.

Objective
The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.
Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested.

A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period.

The lecture 'Vitamins in Heath and Disease' will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.), and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

The selection of plants may be subject to change.

The following important plants and products will be presented and critically discussed as examples (see program below)

1) 21.09.2022: Cimicifuga racemosa; Cannabis sativa

2) 28.9.2022: Lavandula oleum; Echinacea spp.

3) 05.10.2022: Hypericum perforatum

4) 12.10.2022: Silybum marianum; Pelargonium spp.

5) 19.10.2022: Lavandula oleum; Echinacea spp.

6) 26.10.2022: Cimicifuga racemosa; Cannabis sativa

7) 02.11.2022: Exam (Multiple Choice).

Required textbooks:


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5) 19.10.2022: Lavandula oleum; Echinacea spp.

6) 26.10.2022: Cimicifuga racemosa; Cannabis sativa

7) 02.11.2022: Exam (Multiple Choice).

Required textbooks:

Abstract
The lecture is organized as a two-week block during the practical course "Computer-Assisted Drug Design" (535-0023-00 P), totalling 10 two-hour lectures. It provides an introduction to advanced drug design techniques and approaches emphasizing computer-assisted molecular design.

Objective
Participants will learn about computational algorithms and advanced experimental approaches to drug discovery and design, including selected actual topics and practical applications. The contents of the lecture will allow for a deeper understanding of modern computer-assisted drug design methods and how they are linked to experimental applications. The main focus is on computational medicinal chemistry, so that participants will be able to use relevant computer-based methods in own research projects.

Textbook:

Prerequisites / notice
The lecture is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course provides basic knowledge relevant to pharmacy and its application in nephrology, phytotherapy, complementary medicine, wound care and pharmaceutical care.

Objective
Students know and understand the therapeutic concepts of the mentioned topics and their application in practice.

Content
- complementary medicine
- phytotherapy
- wound care
- pharmaceutical care 2
- nephrology

Lecture notes
Provided via myStudies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course provides basic clinical and pharmaceutical knowledge and its application for triage, diagnostics and therapy support for the most common diseases in geriatrics, women's health, oncology, paediatrics and neurology (epilepsy). In addition, the role of nutrition in special life situations and in selected health disorders is taught.

Objective
- know and understand the pathomechanisms and the clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed.
- can triage patients by applying this knowledge: i.e. analyse simple symptoms and disease patterns, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, drug classes and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

Content
- nutrition
- geriatrics
- neurology (epilepsy)
- oncology
- paediatrics
- women's health

Lecture notes
Provided via myStudies.
As specified in the lecture notes

Practical Pharmacy II

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
535-5502-00L | Pharmaceutical Manufacturing in Small Quantities (Compounding) | O | 3 credits | 5G | P. G. Tiefenböck, A. Romagna

**Abstract**
Pharmaceutical Manufacturing relevant for the community pharmacy considering the “GMP-Regeln in kleinen Mengen” of the Pharmacopia: The preparation of extemporaneous products covering the most common forms under consideration of their Risks and Quality Assurance.

**Objective**
The students are able to produce pharmaceutical relevant drug Systems without further assistance, lege artis, applying the right techniques and material. The production and packaging has to follow GMP rules and tailored for the patients need. The quality control and correct documentation have to be followed. The students know the most relevant specifications, concentration and dosing ranges of common APIs and excipients. The students are familiar with the relevant literature (Pharmaceutical and legal basis) regarding the Pharmaceutical manufacturing relevant for the community pharmacies.

**Content**
Vermittlung der wichtigsten Kenntnisse, Arbeitsschritte und -techniken im Bereich der Arzneimittelherstellung in kleinen Mengen (Formula) mit Fokus auf der Herstellung, Qualitätssicherung und Risikobeurteilung einschliesslich der patientenspezifischen Abgabepraxis.

In den Praktika: Anhand praxis-relevanter Beispiele wird die Aufgabenplanung, die Fertigung einschliesslich der korrekte Verwendung der Gerätschaften, die Inprozesskontrolle, die Verpackung und die Qualitätssicherung diverser Rezepte und Arzneiformen geübt. Unter Einbezug risikoadapterter Massnahmen erfolgt die Qualitätssicherung, -kontrolle und Einhaltung von Hygienierichtlinien gemäss den geltenden Arzneibüchern. Die Studierenden vertiefen damit ihre GMP-relevanten Kenntnisse und Fertigkeiten.

**Prerequisites / notice**
Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html

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535-5503-00L | Institutional Pharmacy | O | 2 credits | 3G | P. Wiedemeier, M. Lutters, E. Martinelli, I. S. Vogel Kahmann

**Abstract**
Organisation of institutional environments (emergency hospitals), with special focus on the medication process and institutional pharmaceutical care (continuum of care).

**Objective**
Students understand the concept of continuum of care and its practical implementation. They know the medication process within an institutional environment. They are able to find the necessary information and decide to evaluate them and to communicate and documentate their findings adequately. They know how a hospital is organised (procedures, possible problems), responsibilities of the different members of the staff and, most importantly, what the function of a hospital pharmacy is.

**Content**
Principals of the organisation of institutional environments (emergency hospitals), with special focus on medication processes and institutional pharmaceutical care (circulation of medication, continuum of care). Hygiene regulations, medical products, applications, drug formulations of parentific drugs, SOAP notes, kardex study. Participation at interdisciplinary visits, internal trainings and doctors' reports as well as visitation of the emergency room. Drug interaction, generic substitution, quality management and pharmacovigilance.

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535-5524-00L | Clinical Trainings | O | 2 credits | 3G | A. Gutzeit, D. Stämpfli, P. Wiedemeier

**Abstract**
Basic training on and around patients with practical confrontation. The path of acute patients from patient presentation, through triage and diagnostics to therapy.

**Objective**
Students will be able to understand the medical-clinical way of thinking for the diagnosis and treatment of acute patients. They complete the change of perspective from the molecular mechanism of action of drugs to the treatment of patients in all its complexity. Using real patient examples, students acquire exemplary knowledge in diagnostics and triage as well as therapy selection and therapy support. They consolidate their understanding of the importance of pharmaceutical care before and after hospitalization.

**Content**

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535-5526-00L | Injection Techniques and Vaccinations | O | 2 credits | 3G | I. S. Vogel Kahmann, C. Halin Winter

**Abstract**
Die Studierenden erlernen die praktische Durchführung von subkutanen (s.c.) und intramuskulären (i.m.) Injektionen. Sie wissen, wie in Notfallsituationen vorzugehen ist. Die Besonderheiten von häufig eingesetzten parenteral zu verabreichenden Medikamenten, insbesondere von Impfungen, sind bekannt.

**Objective**
Die Studierenden erwerben das theoretische Wissen und die praktischen Fähigkeiten, welche für die s.c. und i.m. Verabreichung von Medikamenten erforderlich sind. Sie sind fähig, Risikopatienten zu identifizieren und sind geschult, bei Notfällen (z.B. Anaphylaxie) korrekt zu handeln. Die Studierenden kennen die in der Schweiz zur Verfügung stehenden Impfungen, den schweizerischen Impfplan und sind vertraut mit der Anwendung von elektronischen Hilfsmitteln bei Fragestellungen rund um das Impfen. Die Studierenden kennen die rechtlichen Grundlagen und regulatorischen Aspekte bezüglich Impfen in der Apotheke. Die Studierenden kennen verschiedene Verbandmaterialien und können diese anwenden, um akute Wunden zu versorgen.

**Content**

**Lecture notes**
Wird auf mystudies veröffentlicht.

**Literature**
Wird im Skript angegeben.

**Prerequisites / notice**

**Schutzkonzept**
https://chab.ethz.ch/studium/bachelor1.html

Compensatory Courses
The elective courses can be used as compensatory courses.

Science in Perspective
see Science in Perspective: Type A: Enhancement of
Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

see Science in Perspective: Language Courses ETH/UZH

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**Master’s Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>535-0660-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>40D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

**Abstract**

During the Master’s thesis students prove their ability to independent, structured scientific work. The Master’s thesis is usually carried out in a subject area of Pharmaceutical Sciences as chosen by the student.

**Objective**

In the Master Thesis students prove their ability to independent, structured and scientific working.

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**Course Units for Additional Admission Requirements**

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>535-0135-AAL</td>
<td>Clinical Chemistry I</td>
<td>E-</td>
<td>1 credit</td>
<td>2R</td>
<td>M. Hersberger</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction into fundamentals of laboratory diagnostics and overview of the laboratory parameters concerning inflammation, lipid metabolism, myocardial infarction, diabetes, kidney function, urinary diagnostics, liver function, blood coagulation, blood count, therapeutic drug monitoring and drugs of abuse screening.

**Objective**

Overview of the possibilities and limitations in clinical laboratory diagnostics. Indications and methods of everyday parameters are known.

**Content**

Introduction into medical laboratory diagnostics: immunochemical methods, diagnostics of inflammation, acute myocardial infarction, lipid metabolism, diabetes, kidney function and urinary diagnostics, blood coagulation, blood count, therapeutic drug monitoring, drugs of abuse screening, common diagnostics of liver diseases, point-of-care diagnostics.

<table>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0440-AAL</td>
<td>Quality Management in Pharmaceutical Business</td>
<td>E-</td>
<td>1 credit</td>
<td>2R</td>
<td>A. Sterchi</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

The students know the relevance and the role of quality assurance measures to assure quality, efficacy and safety of drugs. The students know the most important Swiss regulations, including the associated European regulations, which are relevant from a quality assurance point of view and they are able to interpret the content of this regulations.

<table>
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<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>406-0603-AAL</td>
<td>Stochastics (Probability and Statistics)</td>
<td>E-</td>
<td>4 credits</td>
<td>9R</td>
<td>M. Kalisch</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

**Objective**

The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

**Content**

From "Statistics for research" (online)

Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"

Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

**Literature**


- "Introductory Statistics with R" by Peter Dalgaard; ISBN 978-0-387-79053-4; DOI: 10.1007/978-0-387-79054-1 From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

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### Pharmacy Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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### Key for Hours

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</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Physicis (General Courses)

### Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
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<td>0 credits</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
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</table>

**Abstract**
Research colloquium

### Physics (General Courses) - Key for Type

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<th>Description</th>
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<td>Recommended, not eligible for credits</td>
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<td>W+</td>
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### Key for Hours

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<td>Lecture with exercise</td>
<td>independent project</td>
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<td>Exercise</td>
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<td>Seminar</td>
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<td>K</td>
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### ECTS

**European Credit Transfer and Accumulation System**

- Special students and auditors need special permission from the lecturers.
First Year

Minor Courses

Science in Perspective

First Year Compulsory Courses

Bachelor Studies (Programme Regulations 2021)

First Year Compulsory Courses

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10</td>
<td>6V+3U</td>
<td>G. Felder</td>
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<tr>
<td>Abstract</td>
<td>Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.</td>
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<tr>
<td>Objective</td>
<td>The ability to work with the basics of calculus in a mathematically rigorous way.</td>
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<table>
<thead>
<tr>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>402-1701-00L</td>
<td>Physics I</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>W. Wegscheider</td>
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<tr>
<td>Abstract</td>
<td>This course gives a first introduction to Physics with an emphasis on classical mechanics.</td>
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<tr>
<td>Objective</td>
<td>Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.</td>
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<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>252-0847-00L</td>
<td>Computer Science</td>
<td>O</td>
<td>5</td>
<td>2V+2U</td>
<td>C. Cotrini Jimenez, F. O. Friedrich Wicker</td>
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<tr>
<td>Abstract</td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
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<tr>
<td>Objective</td>
<td>Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.</td>
<td></td>
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<tr>
<td>Content</td>
<td>The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
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<tr>
<td>Lecture notes</td>
<td>English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.</td>
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<tr>
<td>Literature</td>
<td>Bjørne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
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<td></td>
<td>Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000</td>
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First Year Examination Block 2

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<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>P. Biran, M. Einsiedler</td>
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<tr>
<td>Objective</td>
<td>- Mastering basic concepts of Linear Algebra</td>
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<tr>
<td></td>
<td>- Introduction to mathematical methods</td>
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<tr>
<td>Content</td>
<td>- Basics</td>
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<tr>
<td></td>
<td>- Vectorspaces and linear maps</td>
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<tr>
<td></td>
<td>- Systems of linear equations and matrices</td>
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<td>- Determinants</td>
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<td>- Endomorphisms and eigenvalues</td>
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Lecture notes

We will provide German lecture notes and an English translation at latest at the start of the semester.

Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester. Besides this we also recommend:

In addition we recommend this general introduction into studying mathematics:
- H. Schichl and R. Steinbauer: Einführung in das mathematische Arbeiten. Springer-Verlag 2012. Link:


Second and Third Year Compulsory Courses

Examination Blocks

Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
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<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
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<td>Abstract</td>
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<td>Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.</td>
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<td></td>
<td>Working knowledge of functions of one complex variables; in particular applications of the residue theorem.</td>
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<td>B. Palka: &quot;An introduction to complex function theory.&quot;</td>
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<td>Th. Gamelin: Complex Analysis. Springer 2001</td>
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<td>D. Salamon: &quot;Funktionentheorie&quot;. Birkhauser, 2011. (In German)</td>
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<tr>
<td>402-2203-01L</td>
<td>Classical Mechanics</td>
<td>O</td>
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<td>M. Gaberdiel</td>
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<tr>
<td></td>
<td>A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structures.</td>
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<tr>
<td></td>
<td>Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.</td>
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<td>Y. Chu</td>
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<td>Introductory course on quantum and atomic physics including optics and statistical physics.</td>
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<td>A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.</td>
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<td>Einführung in die Quantenphysik: Planck'sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrsche Atommödell, de-Broglie Materiewellen.</td>
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<td>Optik/Wellenoptik: Linsen, Abbildungssysteme, Brechung und Fermatsches Prinzip, Beugung, Interferenz, Fabry-Perot, Interferometer, Spektrometer.</td>
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<td>Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentialkasten, harmonischer Ozillator</td>
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<td>M. Alonso, E. J. Finn, Quanterphysik und Statistische Physik</td>
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<td>R. Oldenbourg Verlag, München</td>
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<td>S. Auflage</td>
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Examination Block IIa

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<tr>
<td>401-2333-00L</td>
<td>Mathematical Methods of Physics I</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>T. H. Willwacher</td>
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</table>

### Examination Block IIb

Offered in the Spring Semester

### Other Compulsory Courses

no course offering in this semester

### Bachelor Studies (Programme Regulations 2016)

### Second and Third Year Compulsory Courses

#### Examination Block I

<table>
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<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>E. Kowalski</td>
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<tr>
<td>Abstract</td>
<td>Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.</td>
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<td>Objective</td>
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<td>Literature</td>
<td>Th. Gamelin: Complex Analysis. Springer 2001</td>
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<td>Literature</td>
<td>D. Salamon: &quot;Funktionentheorie&quot;. Birkhauser, 2011. (In German)</td>
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<td>K.Jaenich: Funktionentheorie. Springer Verlag</td>
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<td>R.Remmert: Funktionentheorie I. Springer Verlag</td>
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<tr>
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<td>Mathematical Methods of Physics I</td>
<td>O</td>
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<td>3V+2U</td>
<td>T. H. Willwacher</td>
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<table>
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<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>O</td>
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<td>Y. Chu</td>
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<tr>
<td>Abstract</td>
<td>Introductory course on quantum and atomic physics including optics and statistical physics.</td>
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<tr>
<td>Objective</td>
<td>A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.</td>
<td></td>
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<tr>
<td>Content</td>
<td>Einführung in die Quantenphysik: Planck’sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrsche Atommodell, de-Broglie Materiewellen.</td>
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<td>Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentialkasten, harmonischer Oszillator</td>
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<td>M. Alonso, E. J. Finn</td>
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<tr>
<td>Literature</td>
<td>Quantenphysik und Statistische Physik</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>R. Oldenbourg Verlag, München</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>5. Auflage</td>
<td></td>
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<tr>
<td>Literature</td>
<td>ISBN 978-3-486-71340-4</td>
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#### Examination Block II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-2203-01L</td>
<td>Classical Mechanics</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>M. Gaberdiel</td>
</tr>
<tr>
<td>Abstract</td>
<td>A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.</td>
<td></td>
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</tr>
</tbody>
</table>

#### Examination Block III
Quantum Mechanics I

Abstract

Objective
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

Content
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.

Lecture notes
Auf Moodle

Literature
G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Theories not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking not assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Core Courses

Core Courses in Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0263-00L</td>
<td>Astrophysics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>S. Lilly</td>
</tr>
<tr>
<td>Abstract</td>
<td>This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>A comprehensive &quot;script&quot; (240 pages, with detailed derivations) is provided to students. In addition, all powerpoint slides shown in the lectures are provided.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

| 402-0255-00L | Introduction to Solid State Physics        | W    | 10    | 3V+2U | C. Degen         |
| Abstract | The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity. |
| Objective | Introduction to Solid State Physics. |
| Content | The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism, superconductivity. |
| Lecture notes | The script will be available on moodle. |
| Literature | Ibach & Lüth, Festkörperphysik |
| | C. Kittel, Festkörperphysik |
| | Ashcroft & Mermin, Festkörperphysik |
| | W. Känzlig, Kondensierte Materie |
| Prerequisites / notice | Voraussetzungen: Physik I, II, III wünschenswert |

Practical Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0000-01L</td>
<td>Physics Lab 1</td>
<td>O</td>
<td>5</td>
<td>4P</td>
<td>A. Eichler, M. Kroner</td>
</tr>
<tr>
<td>Enrolment is only possible under <a href="https://www.lehrbetrieb.ethz.ch/laborpraktika">https://www.lehrbetrieb.ethz.ch/laborpraktika</a>. No registration required via myStudies. For further information visit: <a href="https://ap.phys.ethz.ch">https://ap.phys.ethz.ch</a></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only students from 3rd Semester BSc Physics on are admitted to Physics Lab 2.</td>
<td></td>
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</tr>
</tbody>
</table>
Introductory lab course in experimental physics

The overarching topic of the student lab is an understanding of the fundamental challenges in experimental physics. The following aspects are particularly important:
- Why does one conduct experiments, and how should an experiment be planned?
- How does one set up an experiment? What are the important characteristics of measurement instruments and methods?
- Introduction to basic statistical data analysis
- Critical interpretation of measurement results
- Scientific communication, reporting, graphic representation of results
- Ethical aspects of experimental research and reporting

Experiments with examples from mechanics, optics, thermodynamics, electricity and radiation.

9 Experiments have to be conducted (typically in teams of 2).

In the first week, only an introductory event is taking place in the lecture hall. This event provides relevant information regarding safety and organisational matters (e.g. testat conditions).

Students must pass an online safety test to be allowed to conduct experiments. Every student must provide an individually adjusted safety goggle.

Students are required to attend a safety lecture on the first day of the course and pass the corresponding online moodle-test before being allowed to access the laboratory rooms and perform the experiments.

The following aspects are emphasized:
- understanding complicated physical phenomena
- structured approach to experiments with complex instruments
- various practical aspects of experimenting and determining uncertainties
- learning the relevant statistical methods for data analysis
- interpretation of measurements and uncertainties
- describing the experiments and the results in a scientifically proper manner, in direct analogy to publishing
- ethical aspects of experimental research and scientific communication

We offer experiments covering the following topics:
- Basic topics from mechanics, optics, thermodynamics, electromagnetism and electronics; as well as central topics from nuclear and particle physics, quantum electronics, quantum mechanics, solid state physics and astrophysics.
- experimental techniques and their methods of analysis and interpretation, as well as error analysis. The experimental work has to be complemented by a concise written report, which trains the scientific writing skills.

Manuals for the individual experiments are available in English.

Students learn to independently perform advanced experiments and document them scientifically correct.

We offer experiments covering the following topics:
- Basic topics from mechanics, optics, thermodynamics, electromagnetism and electronics; as well as central topics from nuclear and particle physics, quantum electronics, quantum mechanics, solid state physics and astrophysics.
- experimental techniques and their methods of analysis and interpretation, as well as error analysis. The experimental work has to be complemented by a concise written report, which trains the scientific writing skills.

Manuals for the individual experiments are available in English.

Students learn to independently perform advanced experiments and document them scientifically correct.

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Students learn to independently perform advanced experiments and document them scientifically correct.

To organise a semester project take contact with one of the instructors.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0210-BSL</td>
<td>Proseminar Theoretical Physics</td>
<td>W</td>
<td>8</td>
<td>4S</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>A guided self-study of original papers and of advanced textbooks in theoretical physics. Within the general topic, determined each semester, participants give a presentation on a particular subject and deliver a written report.</td>
<td></td>
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</tr>
</tbody>
</table>

| 402-0217-BSL | Semester Project in Theoretical Physics | W    | 8    | 15A   | Supervisors       |
| Abstract     | This course unit is an alternative if no suitable "Proseminar Theoretical Physics" is available if the proseminar is already overbooked. Die Leistungskontrolle erfolgt aufgrund eines oder mehrerer schriftlicher Berichte bzw. einer schriftlichen Arbeit. Vorträge können ein zusätzlicher Bestandteil der Leistungskontrolle sein. |
| Prerequisites / notice | 8 Experiments have to be conducted (typically in teams of 2). |

| 402-0215-BSL | Experimental Semester Project in Physics | W    | 8    | 15A   | Supervisors       |
| Abstract     | The aim of the project is to give the student experience in working in a research environment, carrying out physics experiments, analysing and interpreting the resulting data. |
| Prerequisites / notice | Die Leistungskontrolle erfolgt aufgrund eines oder mehrerer schriftlicher Berichte bzw. einer schriftlichen Arbeit. |

| 402-0719-BSL | Particle Physics at PSI (Paul Scherrer Institute) | W    | 8    | 15P   | A. Soter, A. S. Antognini |
| Abstract     | During semester breaks 6-12 students stay for 3 weeks at PSI and participate in a hands-on course on experimental particle physics. A small real experiment is performed in common, including apparatus design, construction, running and data analysis. The course includes some lectures, but the focus lies on the practical aspects of experimenting. |
| Objective    | Students learn all the different steps it takes to perform a complete particle physics experiment in a small team. They acquire skills to do this themselves in the team, including design, construction, data taking and data analysis. |

| 402-0717-BSL | Particle Physics at CERN | W    | 8    | 15P   | W. Lustermann       |
| Abstract     | During semester breaks 6-12 students stay for 3 weeks at PSI and participate in a hands-on course on experimental particle physics. A small real experiment is performed in common, including apparatus design, construction, running and data analysis. The course includes some lectures, but the focus lies on the practical aspects of experimenting. |
| Objective    | Students learn all the different steps it takes to perform a complete particle physics experiment in a small team. They acquire skills to do this themselves in the team, including design, construction, data taking and data analysis. |
During the semester break participating students stay for 4 weeks at CERN and perform experimental work relevant to our particle physics projects. Dates to be agreed upon.

**Objective**

Students learn, by doing, the needed skills to perform a small particle physics experiment: setup, problem solving, data taking, analysis, interpretation and presentation in a written report of publication quality.

**Content**

Detailed information in: https://ethteilchenpraktikumn.web.cern.ch/

**Prerequisites / notice**

Language of instruction: English or German

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>402-0340-BSL</td>
<td>Medical Physics</td>
<td>W</td>
<td>8 credits</td>
<td>15P</td>
<td>A. J. Lomax, K. P. Prüssmann</td>
</tr>
<tr>
<td>402-0000-10L</td>
<td>Physics Lab 4</td>
<td>W</td>
<td>8 credits</td>
<td>15P</td>
<td>M. Donegá, S. Gvasaliya</td>
</tr>
</tbody>
</table>

Enrol at most once in the course of the Bachelor programme!

**Abstract**

This laboratory course provides basic training of experimental skills. These are experimental design, implementation, measurement, data analysis and interpretation, as well as error analysis. The experimental work has to be complemented by a concise written report, which trains the scientific writing skills.

**Objective**

Students learn to independently perform advanced experiments and document them scientifically correct.

The following aspects are emphasized:
- understanding complicated physical phenomena
- structured approach to experiments with complex instruments
- various practical aspects of experimenting and determining uncertainties
- learning the relevant statistical methods for data analysis
- interpretation of measurements and uncertainties
- describing the experiments and the results in a scientifically proper manner, in direct analogy to publishing
- ethical aspects of experimental research and scientific communication

**Content**

We offer experiments covering the following topics:
Basic topics from mechanics, optics, thermodynamics, electromagnetism and electronics; as well as central topics from nuclear and particle physics, quantum electronics, quantum mechanics, solid state physics and astrophysics.

**Prerequisites / notice**

From a variety of over 50 experiments, students have to perform 4 experiments covering different topics. The experimental work is complemented by writing a scientific report.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

**Lecture notes**

Instructions for experiments are available in English.

**Science in Perspective**

**Language Courses**

**Additional Courses, Seminars and Colloquia**

**First or Second Year Additional Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0351-00L</td>
<td>Astronomy</td>
<td>Z</td>
<td>2 credits</td>
<td>2V</td>
<td>H. M. Schmid, A. M. Glauser</td>
</tr>
</tbody>
</table>

**Abstract**

An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology

**Objective**

This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.

**Content**

Pianeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie.

**Literature**

Der Neue Kosmos. A. Unsöld, B. Baschek, Springer

Oder sonstige Grundlehrbücher zur Astronomie.

**Additional Courses (from Second Year Mathematics Bachelor)**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2003-00L</td>
<td>Algebra I</td>
<td>Z</td>
<td>7 credits</td>
<td>3V+2U</td>
<td>R. Pink</td>
</tr>
</tbody>
</table>
Abstract
Introduction and development of some basic algebraic structures - groups, rings, fields.

Objective
Introduction to basic notions and results of group, ring and field theory.

Content
Group Theory: basic notions and examples of groups, subgroups, factor groups, homomorphisms, group actions, Sylow theorems, applications

Ring Theory: basic notions and examples of rings, ring homomorphisms, ideals, factor rings, Euclidean rings, principal ideal domains, factorial rings, applications

Field Theory: basic notions and examples of fields, field extensions, algebraic extensions, applications

Literature
Karpfinger-Meyberg: Algebra, Spektrum Verlag
S. Bosch: Algebra, Springer Verlag
B.L. van der Waerden: Algebra I und II, Springer Verlag
S. Lang, Algebra, Springer Verlag
A. Knapp: Basic Algebra, Springer Verlag
J.F. Humphreys: A Course in Group Theory (Oxford University Press)
G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)
M. Artin: Algebra (Birkhaeuser Verlag)

Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
<tr>
<td>402-0800-00L</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>J. Renes, University lecturers</td>
</tr>
<tr>
<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>A. Cattaneo, G. Felder, M. Gaberdiel, G. M. Graf, P. Hintz, T. H. Willwacher</td>
</tr>
<tr>
<td>402-0600-00L</td>
<td>Nuclear and Particle Physics with Applications</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>A. Rubbia, K. S. Kirch</td>
</tr>
<tr>
<td>402-0893-00L</td>
<td>Particle Physics Seminar</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>T. K. Gehrmann</td>
</tr>
<tr>
<td>402-0700-00L</td>
<td>Seminar in Elementary Particle Physics</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>M. Spira, University lecturers</td>
</tr>
<tr>
<td>402-0746-00L</td>
<td>Seminar: Particle and Astrophysics (Aktuelles aus der E-Teilchen- und Astrophysik)</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>University lecturers</td>
</tr>
<tr>
<td>402-0300-00L</td>
<td>IPA Colloquium</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>A. Bilander, A. de Costa, A. Refregier, H. M. Schmid, further lecturers</td>
</tr>
<tr>
<td>402-0530-00L</td>
<td>Mesoscopic Systems</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>T. M. Ihn</td>
</tr>
<tr>
<td>227-0980-00L</td>
<td>Seminar on Biomedical Magnetic Resonance</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>K. P. Prüssmann, S. Kozerke, M. Weiger Senften</td>
</tr>
<tr>
<td>227-1043-00L</td>
<td>Neuroinformatics - Colloquia (University of Zurich)</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>S.-C. Liu, R. Hahnloser, V. Mante</td>
</tr>
</tbody>
</table>

Additional information:
- Special Students UZH must book the modul PHY463 directly at UZH.
- Stay informed about current research results in elementary particle physics.
- Currently, talks may be delivered in German.
- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: INI701
- Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html
402-0396-00L Recent Research Highlights in Astrophysics (University of Zurich)

**Title**
Recent Research Highlights in Astrophysics

**Abstract**
This lecture provides an overview of current research in the field of Astro-Particle Physics, including the different experimental techniques.

**Objective**
The goal of this lecture is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.

**Content**
The topics depend heavily on the invited speakers, and thus change from week to week.

**Selection of Higher Semester Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>W</td>
<td>5 credits</td>
<td>4G</td>
<td>R. Käppeli</td>
</tr>
<tr>
<td>402-0713-00L</td>
<td>Astro-Particle Physics I</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>A. Biland</td>
</tr>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
</tbody>
</table>

**Objective**
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.
Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

402-0461-00L Quantum Information Theory W 8 credits 3V+1U J. Renes

Abstract
The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.

Objective
By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.

Content
Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

Lecture notes Distributed via moodle.

Literature
Nielsen and Chuang, Quantum Information and Computation
Preskill, Lecture Notes on Quantum Computation
Wilde, Quantum Information Theory
Watrous, The Theory of Quantum Information

402-0580-00L Superconductivity W 6 credits 2V+1U M. Sigrist

Abstract
Superconductivity; thermodynamics, London and Pippard theory; Ginzburg-Landau theory; spontaneous symmetry breaking, flux quantization, type I and II superconductors; microscopic BCS theory: electron-phonon mechanism, Cooper pairing, quasiparticle spectrum, thermodynamics and response to magnetic fields. Josephson effect: superconducting quantum interference devices (SQUID) and other applications.

Objective
Introduction to the most important concepts of superconductivity both on phenomenological and microscopic level, including experimental and theoretical aspects.

Content
This lecture course provides an introduction to superconductivity, covering both experimental as well as theoretical topics. The following topics are covered:

- Basic phenomena of superconductivity: thermodynamics, electrodynamics, London and Pippard theory; Ginzburg-Landau theory: spontaneous symmetry breaking, flux quantization, properties of type I and II superconductors; mixed phase; microscopic BCS theory: electron-phonon mechanism, Cooper pairing, coherent state, quasiparticle spectrum, thermodynamics and response to magnetic fields; Josephson effect, superconducting quantum interference devices (SQUID) and other applications.

Lecture notes
Lecture notes and additional materials are available.

Literature
P. G. de Gennes “Superconductivity Of Metals And Alloys”
A. A. Abrikosov “Fundamentals of the Theory of Metals”
J. B. Ketterson & S. N. Song “Superconductivity”
H. Stolz “Supraleitung” (German)
K. Fossheim & A. Sudbo “Superconductivity: Physics and Applications”

Prerequisites / notice
The preceding attendance of the scheduled lecture courses “Introduction to Solid State Physics” and “Quantum Mechanics I” are mandatory. The lectures “Quantum Mechanics II” and “Solid State Theory” provide the most optimal conditions to follow this course.

Electives (Physics Master)

402-0674-00L Physics in Medical Research: From Atoms to Cells W 6 credits 2V+1U B. K. R. Müller

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

Objective
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocore behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure’s shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue’s anisotropies of biopsies.

227-1037-00L Introduction to Neuroinformatics W 6 credits 2V+1U+1A V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. van der Behrens
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monoculars of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

401-3531-00L Differential Geometry I
At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- John M. Lee: Introduction to Smooth Manifolds
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie. Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

401-3461-00L Functional Analysis I
At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory


401-3601-00L Probability Theory
At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory


Recommended references include the following:

Objectives / notice
Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory; in part: Lebesgue integration and L^p spaces).
can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3645-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

401-3621-00L
Abstract: Basics of probability theory and the theory of stochastic processes in discrete time
Objective: This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content: This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes will be available in electronic form.

Literature:
- H. Bauer, Probability Theory, de Gruyter 1996
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- D. Williams, Probability with martingales, Cambridge University Press 1991

402-0247-00L
Abstract: Fundamentals of Mathematical Statistics
Objective: The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

Content: Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC's and DAC's, introduction in CMOS technology.

Prerequisites / notice: no prior knowledge in electronics is required

Taught competencies:
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Problem-solving
- Social Competencies: Cooperation and Teamwork
- Personal Competencies: Critical Thinking

402-0010-00L
Abstract: Basics of Computing Environments for Scientists
Objective: Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists.

The "IT at D-PHYS" introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.

The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges.

The "Linux Basics" modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization.

The "Python Ecosystem" modules present various aspects on the ecosystem around Python, without covering the programming language itself. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing code. From development environments (IDE, Jupyter), over code formatters and linters, to skimming selected concepts (string formatting, regular expressions).

The "System Aspects module" deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it.

Use the dedicated web page https://www.lehrbetrieb.ethz.ch/laborpraktika to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to https://compenv.phys.ethz.ch for the detailed contents.
Content

Introduction:

IT at D-PHYS (IT service providers and IT services at D-PHYS)

Modules:

Linux Basics I (system components, basic shell usage)
Linux Basics II (advanced tools, scripting)
Python Ecosystem I (interpreters, packages, virtual environments)
Python Ecosystem II (development environments, formatter and linter, string formatting, regexp)
System Aspects (how the hardware affects your scientific code and vice versa)

<table>
<thead>
<tr>
<th>Physics Bachelor - Key for Type</th>
<th></th>
<th>Z</th>
<th>Courses outside the curriculum</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<th>Key for Hours</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<tr>
<th>ECTS</th>
<th>European Credit Transfer and Accumulation System</th>
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<tr>
<td></td>
<td>Special students and auditors need special permission from the lecturers.</td>
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</table>
### Educational Science

**General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC."**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>E. Stern</td>
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<td></td>
<td>This course looks into scientific theories and also empirical</td>
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<td></td>
<td>studies on human learning and relates them to the school.</td>
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<td>Abstract</td>
<td>Anyone wishing to be a successful teacher must first of all understand</td>
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<td></td>
<td>the learning process. Against this background, theories and findings</td>
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<td></td>
<td>on the way humans process information and on human behaviour are</td>
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<td>prepared in such a manner that they can be used for planning and</td>
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<td>conducting lessons. Students additionally gain an understanding of</td>
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<td>what is going on in learning and behavioural research so that teachers</td>
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<td>are put in a position where they can further educate themselves in the</td>
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<td></td>
<td>field of research into teaching and learning.</td>
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<tr>
<td>Objective</td>
<td>Lernformen: Theorien und wissenschaftliche Konstruktoren werden</td>
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<td></td>
<td>zusammen mit ausgewählten wissenschaftlichen Untersuchungen in Form</td>
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<td></td>
<td>einer Vorlesung präsentiert. Die Studierenden vertiefen nach jeder Stunde</td>
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<td></td>
<td>die Inhalte durch die Bearbeitung von Aufträgen in einem elektronischen</td>
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<td></td>
<td>Lerntagebuch. Über die Bedeutung des Gelernten für den Schulalltag soll</td>
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<td></td>
<td>reflektiert werden. Ausgewählte Tagebucheinträge werden zu Beginn jeder</td>
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<td>Vorlesung thematisiert.</td>
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<tr>
<td>Literature</td>
<td>Folien werden zur Verfügung gestellt.</td>
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<td>Prerequisites / notice</td>
<td>This course is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
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<tr>
<td>851-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W2)</td>
<td>W</td>
<td>2 credits</td>
<td>3S</td>
<td>U. Markwalder, S. Maurer, S. Peteranderl-Rüschoff</td>
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<tr>
<td></td>
<td>Students possess theoretical knowledge and practical competences to be</td>
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<td>able to cope with the psychosocial demands of teaching.</td>
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<td>Objective</td>
<td>(1) They know relevant rules of conversation and conflict management</td>
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<td>and are able to apply them in an appropriate way in the school</td>
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<td>context (e.g. in parental talks).</td>
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<td>(2) They know core aspects of classroom management and know how to</td>
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<td>apply it concretely (e.g. promoting a positive learning atmosphere,</td>
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<td>avoiding disciplinary difficulties) and they are aware of possible</td>
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<td>contacts (e.g. illegal or psychological services).</td>
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<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects (EW4 W2)</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Schumacher</td>
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<td></td>
<td>This course unit can only be enrolled after successful</td>
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<td></td>
<td>participation in, or during enrollment in the course &quot;Human Learning</td>
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<td>(EW4 W2) is recommended, but not a mandatory prerequisite.</td>
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<td>Objective</td>
<td>This seminar focuses on teaching units in chemistry, physics and</td>
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<td>mathematics that have been developed at the MINT Learning Center of the</td>
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<td>ETH Zurich. In the first meeting, the mission of the MINT Learning</td>
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<td>Center will be communicated. Furthermore, in groups of two, the</td>
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<td>students will intensively work on, refine and optimize a teaching</td>
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<td>unit following a goal set in advance.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This course is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
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<tr>
<td>851-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>E. Stern</td>
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<td>This course unit can only be enrolled after successful</td>
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<td>participation in, or during enrollment in the course &quot;Human Learning</td>
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<td>(EW4 W2).</td>
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<td>Objective</td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre</td>
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<td>Folgen&quot; by Stern and Neubauer. Participation at the first meeting</td>
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<td>is obligatory. It is required that all participants read the complete</td>
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<td>book. Furthermore, in two meetings of 90 minutes, concept papers</td>
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<td>developed in small groups (5 - 10 students) will be discussed.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This course is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
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<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>C. M. Thurn, T. Braas, P. Edelsbrunner</td>
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<td>This course unit can only be enrolled after successful</td>
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<tr>
<td></td>
<td>participation in, or during enrollment in the course &quot;Human Learning</td>
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**Data:** 18.08.2022 12:39  
**Autumn Semester 2022**  
**Page 1811 of 2345**
Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

**Gender Issues In Education and STEM**

**Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).**

**Prerequisite:** students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

**Abstract**
In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls in women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

**Objective**
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher's work.

**Content**
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and literature from the learning sciences is critically discussed with a focus on research methods.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

**Prerequisites / notice**
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

**Formation of Knowledge in STEM Fields in Primary and Secondary School**

**Abstract**
The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of students assist primary and secondary school teachers in STEM lessons.

**Objective**
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

**Content**
Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions of students in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

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**Subject Didactics and Professional Training**

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

**Physics Didactics I: Special Didactics of Physics Teaching**

**Number** 402-0910-00L

**Type** O

**ECTS** 4 credits

**Hours** 3G

**Lecturers** M. Mohr

Further information is available from the lecturer via email:
mohr@ethz.ch

Simultaneous enrolment in Introductory Internship Physics - course 402-0920-00L - is compulsory for Teaching Diploma Physic

**Objective**
Die Studierenden verfügen über fachdidaktisches Grundwissen für den Physikunterricht an einer Mittelschule. Sie können eigene Lektionen unter Berücksichtigung der vielfältigen Rahmenbedingungen planen, durchführen und evaluieren. Sie reflektieren ihren Unterricht und sind bestrebt, ihn didaktisch und pädagogisch weiter zu entwickeln.

Die Studierenden kennen die Einsatzmöglichkeiten, Chancen und Schwierigkeiten verschiedener Unterrichtsformen und Hilfsmittel. Sie können die Eignung von Unterrichtsformen im Hinblick auf eine Lernsituation beurteilen. Sie bemühen sich in ihrem Unterricht, geeignete Methoden und Medien angepasst an die Klasse und das Thema einzusetzen.

Content
Themenatische Schwerpunkte
Fachspezifisches: Sachstrukturen der gängigen Unterrichtsthemen, Alltagsbezüge, Fehlvorstellungen, Demonstrations- und Schülerexperimente, Arbeitsmittel zu physikalischen Themen des Grundlagen- und Schwerpunktunterrichts
Einsatz verschiedener Unterrichtsmaterialien: Experimente, Computer, Taschenrechner, Video, Simulation
Unterrichtsformen: Lernaufgabe, Werkstatt, Puzzle, Projekt, Gruppenarbeit, Praktikum
Lernformen
Interaktive Lehr-Lernveranstaltung mit Vorträgen und Demonstrationen des Dozenten, studentischer Einzel- und Kleingruppenarbeit, kurzen Präsentationen der Studierenden, Verbrieflich der Inhalte durch Bearbeitung von Aufträgen ausserhalb der Kontaktstunden

402-0915-00L Teaching Internship Including Examination Lessons  O  4 credits  9P  M. Mohr
Physics
Teaching Internship Physics for TC.
Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.

Abstract
Students insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Die Themen für die beiden Prüfungslektionen am Schluss des Praktikums erfahren die Studierenden in der Regel eine Woche vor dem Prüfungstermin. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie bis am Vortrag um 12 Uhr den beiden Prüfungsexperten (Fachdidaktiker/-in, Departementsvertreter/-in) ein. Die gehaltenen Lektionen werden kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltenen Lektionen im Rahmen eines kurzen Kolloquiums.

402-0917-00L Mentored Work Subject Didactics Physics A  O  2 credits  4A  G. Schiltz, A. Vaterlaus
Teaching Diploma

Abstract
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

Objective
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content
Thematic Focus
The topics of the mentored work are mostly chosen from the high school curriculum.

Lecture notes
http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

Prerequisites / notice
The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.

402-0917-00L Mentored Work Subject Didactics Physics A  O  2 credits  4A  G. Schiltz, A. Vaterlaus
Teaching Diploma

Abstract
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

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- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content
Thematic Focus
The topics of the mentored work are mostly chosen from the high school curriculum.

Lecture notes
http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

Prerequisites / notice
The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1813 of 2345
Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Negotiation
- Adaptability and Flexibility
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Self-awareness and Self-reflection
- Self-direction and Self-management

Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
</tbody>
</table>

Abstract
Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts. How much energy do we need and can it be provided in a way that allows for sustainable existence?

Objective
- Why is energy important for life and our society?
- How did energy use change over time? Which effects did these changes have on the environment?
- What are the physical basics of energy technologies?
- When, why and how did technology and science of energy come together?
- What are the limits and benefits of all the various energy technologies?
- How can different energy technologies be compared?
- Can we understand the changes in the current energy systems?
- How will the energy systems of the future look like?
- How fast can we and should we enforce the current energy transition?
- Which could be the overall guidelines for a working energy system of the future?

Content
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature
- The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
- Clean Disruption of Energy and Transportation, T. Seba 2014
- Energy and Civilization: A History, V. Smil, 2018

Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology. Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions. Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

402-0922-00L Mentored Work Specialised Courses in Physics with an Educational Focus A

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
Practice in the explanation of complex topics in physics as the core competence of the teaching profession

Content
Choice of topic by individual arrangement
Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

402-0247-00L Electronics for Physicists I (Analogue) W 4 credits 2V+2P G. Bison, W. Erdmann

Abstract
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology.

Objective
The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

Content
Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC's and DAC's, introduction in CMOS technology.

Practical exercises in small groups to the above themes complement the lectures.

Prerequisites / notice
no prior knowledge in electronics is required

Taught competencies

Subject-specific Competencies
Concepts and Theories not assessed
Techniques and Technologies not assessed

Method-specific Competencies
Problem-solving not assessed

Social Competencies
Cooperation and Teamwork not assessed

Personal Competencies
Creative Thinking not assessed
Critical Thinking not assessed

402-0869-00L Qualitative Methods in Physics W 6 credits 2V+1U V. Geshkenbein

Abstract
We will discuss, how qualitative thinking allows to progress in different areas of physics, from classical to quantum mechanics, from phase transitions, to developed turbulence and Anderson localisation.

Objective
The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most attractive and beautiful characteristic of this discipline. However, as experience shows, it is just these aspects which are most difficult for beginner. Unfortunately, the methods of theoretical physics are usually presented in a formal, mathematical way, rather than in the constructive form in which they are used in scientific work. The purpose of this lecture course is to make up this deficiency.

Lecture notes
Lecture notes and additional materials are available.

Physics TC - Key for Type

O  Compulsory
W+  Eligible for credits and recommended
W  Eligible for credits
E-  Recommended, not eligible for credits
Z  Courses outside the curriculum
Dr  Suitable for doctorate

Key for Hours

V  lecture
G  lecture with exercise
U  exercise
S  seminar
K  colloquium
P  practical/laboratory course
A  independent project
D  diploma thesis
R  revision course / private study

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Physics Teaching Diploma

Detailed information on the programme at: www.didaktischeausbildung.ethz.ch

Educational Science

Course offerings in the category Educational Science are listed under “Programme: Educational Science for Teaching Diploma and TC”.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects  ■ W</td>
<td></td>
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<td>2S</td>
<td>R. Schumacher</td>
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<td>Enrolment only possible matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.</td>
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<td>Prerequisites /</td>
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<tr>
<td>Objective</td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<tr>
<td>Abstract</td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<tr>
<td>851-0242-07L</td>
<td>Human Intelligence  ■ W</td>
<td></td>
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<td>1S</td>
<td>E. Stern</td>
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<td>Number of participants limited to 30.</td>
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<td>Objective</td>
<td>- Understanding research methods used in the empirical human sciences</td>
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<td>- Getting to know intelligence tests</td>
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<td>- Understanding findings relevant for education</td>
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<tr>
<td>Abstract</td>
<td>The focus will be on the book “Intelligenz: Grosse Unterschiede und ihre Folgen” by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science  ■ W</td>
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<td>2S</td>
<td>C. M. Thurn, T. Braas, P. Edelsbrunner</td>
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<td>Enrolment only possible matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td>Objective</td>
<td>- Understand research methods used in the empirical educational sciences</td>
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<td>- Understand and critically examine information from scientific journals and media</td>
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<td>- Understand pedagogically relevant findings from the empirical educational sciences</td>
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<tr>
<td>Abstract</td>
<td>Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.</td>
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<tr>
<td>851-0242-11L</td>
<td>Gender Issues in Education and STEM  ■ W</td>
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<td>2S</td>
<td>M. Berkowitz Biran, T. Braas, C. M. Thurn</td>
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<td>Objective</td>
<td>- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues</td>
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<td>- To develop a critical view on existing research and perspectives.</td>
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<td>- To integrate this knowledge with teacher’s work.</td>
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<td>Content</td>
<td>Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them. The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.</td>
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<td>402-0910-00L</td>
<td>Physics Didactics I: Special Didactics of Physics Teaching ■ O</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Mohr</td>
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</tbody>
</table>

Subject Didactics in Physics

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
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<tr>
<td>851-0240-00L</td>
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see Educational Science Teaching Diploma

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Simultaneous enrolment in Introductory Internship Physics - course 402-0920-00L - is compulsory for Teaching Diploma Physic

Objective

Die Studierenden verfügen über fachdidaktisches Grundwissen für den Physikunterricht an einer Mittelschule. Sie können eigene Lektionen unter Berücksichtigung der vielfältigen Rahmenbedingungen planen, durchführen und evaluieren. Sie reflektieren ihren Unterricht und sind bestrebt, ihn didaktisch und pädagogisch weiter zu entwickeln.

Die Studierenden kennen die Einsatzmöglichkeiten, Chancen und Schwierigkeiten verschiedener Unterrichtsmethoden und Hilfsmittel. Sie können die Eignung von Unterrichtsformen im Hinblick auf eine Lernsituation beurteilen. Sie bemühen sich in ihrem Unterricht, geeignete Methoden und Medien angepasst an die Klasse und das Thema einzusetzen.


Content

Thematische Schwerpunkte
Fachspezifisches: Sachstrukturen der gängigen Unterrichtsthemen, Alltagsbezüge, Fehlvorstellungen, Demonstrations- und Schülerexperimente, Arbeitsmittel zu physikalischen Themen des Grundlagen- und Schwerpunktsunterrichts
Einsatz verschiedener Unterrichtsmaterialien: Experimente, Computer, Taschenrechner, Video, Simulation
Unterrichtsformen: Lernaufgabe, Werkstatt, Puzzle, Projekt, Gruppenarbeit, Praktikum
Lernformen
Interaktive Lehr-Lernveranstaltung mit Vorträgen und Demonstrationen des Dozenten, studentischer Einzel- und Kleingruppenarbeit, kurzen Präsentationen der Studierenden, Veröff. der Inhalte durch Bearbeitung von Aufträgen ausserhalb der Kontaktstunden

Lecture notes
Folien und weitere Unterlagen werden zur Verfügung gestellt

Literature

Prerequisites / notice

Die Veranstaltung ist zusammen mit dem Einführungspraktikum zu belegen

402-0917-00L Mentored Work Subject Didactics Physics A

Mentored Work Subject Didactics in Physics for TC and Teaching Diploma.

Objective

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.

- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Thematic Focus
The topics of the mentored work are mostly chosen from the high school curriculum.

Methods
With the help of the mentor the students individually work on a topic and write a thesis about it.

Lecture notes
http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

Prerequisites / notice

The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.

Taught competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

402-0918-00L Mentored Work Subject Didactics Physics B

Mentored Work Subject Didactics in Physics for TC and Teaching Diploma.

Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

The topics of the mentored work are mostly chosen from the high school curriculum.

Methods
With the help of the mentor the students individually work on a topic and write a thesis about it.

http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Simultaneous enrolment in Physics Didactics: Special Didactics of Physics Teaching - course 402-0910-00L - is compulsory.

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<thead>
<tr>
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</tr>
</thead>
<tbody>
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<td>402-0920-00L</td>
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<td>O</td>
<td>3</td>
<td>6P</td>
<td>M. Mohr</td>
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<td>402-0911-00L</td>
<td>Teaching Internship Physics ■</td>
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<td>- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.</td>
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<td>- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.</td>
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<td>- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.</td>
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<td>W</td>
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<td>9P</td>
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Methods
With the help of the mentor the students individually work on a topic and write a thesis about it.

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The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

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</table>
This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures and is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

**Objective**
Die Studierenden können die Bedeutung von Unterrichtsthemen in ihrem Fach unter verschiedenen Blickwinkeln einschätzen. Sie kennen und beherrschen das unterrichtliche Handwerk. Sie können ein gegebenes Unterrichtsthema für eine Gruppe von Lernenden fachlich und didaktisch korrekt strukturieren und in eine adäquate Lernumgebung umsetzen. Es gelingt ihnen, die Balance zwischen Anleitung und Offenheit zu finden, sodass die Lernenden sowohl über den nötigen Freiraum wie über ausreichend Orientierung verfügen, um aktiv und effektiv flexibel nutzbares (Fach-)Wissen zu erwerben.

**Content**

**402-0921-01L** Examination Lesson I Physics O 1 credit 2P M. Mohr

**Abstract**
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

**Objective**
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

**Content**
Die Studierenden erfahren das Lektionsthema in der Regel eine Woche vor dem Prüfungstermin. Von der zuständigen Lehrperson erhalten sie Informationen über den Wissensstand der zu unterrichtenden Klasse und können sie vor dem Prüfungstermin besuchen. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie bis am Vortag um 12 Uhr den beiden Prüfungsexperten ein.

Die gehaltene Lektion wird kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/ der Kandidatin über die gehaltene Lektion im Rahmen eines kurzen Kolloquiums.

**Lecture notes / notice**
Nach Abschluss der übrigen Ausbildung.

**402-0921-02L** Examination Lesson II Physics O 1 credit 2P M. Mohr

Simultaneous enrolment in "Examination Lesson I Physics" (402-0921-01L) is compulsory.

**Abstract**
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

**Objective**
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

**Content**
Die Studierenden erfahren das Lektionsthema in der Regel eine Woche vor dem Prüfungstermin. Von der zuständigen Lehrperson erhalten sie Informationen über den Wissensstand der zu unterrichtenden Klasse und können sie vor dem Prüfungstermin besuchen. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie bis am Vortag um 12 Uhr den beiden Prüfungsexperten ein.

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**Lecture notes / notice**
Nach Abschluss der übrigen Ausbildung.

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Core courses that counted towards the Bachelor or Master programme in physics or comprised additional admission requirements in subject didactics are not eligible for the teaching diploma.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0351-00L</td>
<td>Astronomy</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>H. M. Schmid, A. M. Glauser</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology</td>
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<tr>
<td><strong>Objective</strong></td>
<td>This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie.</td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Kopien der Präsentationen werden zur Verfügung gestellt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Literature</strong></td>
<td>Der Neue Kosmos, A. Unsöld, B. Baschek, Springer</td>
<td></td>
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<tr>
<td>Oder sonstige Grundlehrbücher zur Astronomie.</td>
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</tbody>
</table>

| 402-0737-00L | Energy and Sustainability in the 21st Century (Part I) | W | 6 credits | 2V+1U | P. Morf |
| **Abstract** | Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts. How much energy do we need and can it be provided in a way that allows for sustainable existence? |
| **Objective** | Why is energy important for life and our society? How did energy use change over time? Which effects did these changes have on the environment? What are the physical basics of energy technologies? When, why and how did technology and science of energy come together? What are the limits and benefits of all the various energy technologies? How can different energy technologies be compared? Can we understand the changes in the current energy systems? How will the energy systems of the future look like? How fast can we and should we enforce the current energy transition? Which could be the overall guide lines for a working energy system of the future? |

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Data: 18.08.2022 12:39
Autumn Semester 2022
Page 1819 of 2345
### Content
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
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11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

### Literature
- The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
- Clean Disruption of Energy and Transportation, T. Seba 2014
- Energy and Civilization: A History, V. Smil, 2018

### Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

### 402-0922-00L Mentored Work Specialised Courses in Physics with an Educational Focus A

**Abstract**
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

**Objective**
Practice in the explanation of complex topics in physics as the core competence of the teaching profession.

**Content**
Choice of topic by individual arrangement

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods and Technologies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Assessed</td>
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<tr>
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<tr>
<td>Sensitivity to Diversity</td>
<td>Negotiation</td>
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</tbody>
</table>

### 402-0923-00L Mentored Work Specialised Courses in Physics with an Educational Focus B

**Abstract**
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

**Objective**
Practice in the explanation of complex topics in physics as the core competence of the teaching profession.

**Content**
Choice of topic by individual arrangement

Internship Physics Didactics

402-0924-00L

Abstract
During the Internship Physics Didactics students teach 8 lessons in the classes of an internship teaching person. Students develop, test and analyze teaching arrangement under the guidance of a mentor (one of the lecturers).

Objective
Basic knowledge for the design of teaching arrangements is the topic of the Physics Didactics I and II courses. In the subsequent Internship Physics Didactics students combine the theoretical knowledge acquired in the didactics courses with practical aspects of teaching. During the internship students learn to transform their teaching goals into a real live class room setting considering subject specific, didactical and pedagogical aspects.

Content

Lecture notes
Wird vom Mentor bestimmt.

Prerequisites / notice
Das Fachdidaktikpraktikum kann erst nach dem Besuch der FD1 und frühestens mit der FD2 durchgeführt werden (eine gleichzeitige Belegung von Fachdidaktik 2 und Fachdidaktikpraktikum ist möglich).

Astrophysics I

402-0263-00L

Abstract
This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.

Objective
The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.

Lecture notes
A comprehensive "script" (240 pages, with detailed derivations) is provided to students. In addition, all powerpoint slides shown in the lectures are provided.

Introduction to Solid State Physics

402-0255-00L

Abstract
The course provides an introduction to solid-state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.

Objective
Introduction to Solid State Physics.

Content
The course provides an introduction to solid-state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.

Lecture notes
The script will be available on moodle.

Literature
- Itzhaki & Lüth, Festkörperphysik
- Kittel, Festkörperphysik
- Ashcroft & Mermin, Festkörperphysik
- Känzig, Kondensierte Materie

Prerequisites / notice
We will discuss, how qualitative thinking allows to progress in different areas of physics, from classical to quantum mechanics, from phase transitions, to developed turbulence and Anderson localisation.

The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most attractive and beautiful characteristic of this discipline. However, as experience shows, it is just these aspects which are most difficult for the beginner. Unfortunately, the methods of theoretical physics are usually presented in a formal, mathematical way, rather than in the constructive form in which they are used in scientific work. The purpose of this lecture course is to make up this deficiency.

Lecture notes
Lecture notes and additional materials are available.

Compulsory Elective Courses
Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

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<td>6 credits</td>
<td>2V+1U</td>
<td>P. Morf</td>
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Abstract
Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts.

Objective
Why is energy important for life and our society?
How did energy use change over time? Which effects did these changes have on the environment?
What are the physical basics of energy technologies?
When, why and how did technology and science of energy come together?
What are the limits and benefits of all the various energy technologies?
How can different energy technologies be compared?
Can we understand the changes in the current energy systems?
How will the energy systems of the future look like?
How fast can we and should we enforce the current energy transition?
Which could be the overall guide lines for a working energy system of the future?

Content
1. Introduction to Energy – what is it all about
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3. Coal, oil and natural gas – fossil fuels
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Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology. Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

252-0855-00L Computer Science in Secondary School Mathematics | W | 4 credits | 3G | J. Hromkovic, G. Serafini |

Abstract
The unit "Computer Science in Secondary School Mathematics" addresses key contributions of computer science to general education, the close relations between the algorithmic and the mathematical way of thinking, and the thoughtful choice of computer science topics for high school mathematics classes.

Objective
The general goal of the course consists in presenting ways to teach fundamentals of computer science, which are closely related to contents and methods of mathematics. After attending the course unit, a mathematics teacher is able to teach selected fundamentals of computer science in mathematics classes.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

Content
The main topics of the course unit "Computer Science in Secondary School Mathematics" represent a scientific and didactic added value for mathematics classes.

The course covers the didactics of logic, of cryptography, of finite state automata, of computability and of the introduction to programming.

The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes
Literatur wird angegeben. Zusätzliche Unterlagen und Folien werden zur Verfügung gestellt.
Literature

J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen" Lehrwerksreihe "Einfach Informatik"
https://einfachinformatik.inf.ethz.ch/


Electronics for Physicists I (Analogue)

Number of participants limited to 40.

<table>
<thead>
<tr>
<th>402-0247-00L</th>
<th>Electronics for Physicists I (Analogue)</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2P</th>
<th>G. Bison, W. Erdmann</th>
</tr>
</thead>
</table>

Abstract
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology

Objective
The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. These include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

Content
Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC’s and DAC’s, introduction in CMOS technology.

Practical exercises in small groups to the above themes complement the lectures.

Prerequisites / notice
No prior knowledge in electronics is required.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>not assessed</th>
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</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Problem-solving</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
<td>not assessed</td>
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</tbody>
</table>

Qualitative Methods in Physics

<table>
<thead>
<tr>
<th>402-0869-00L</th>
<th>Qualitative Methods in Physics</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>V. Geshkenbein</th>
</tr>
</thead>
</table>

Abstract
We will discuss, how qualitative thinking allows to progress in different areas of physics, from classical to quantum mechanics, from phase transitions, to developed turbulence and Anderson localisation.

Objective
The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most attractive and beautiful characteristic of this discipline. However, as experience shows, it is just these aspects which are most difficult for beginner. Unfortunately, the methods of theoretical physics are usually presented in a formal, mathematical way, rather than in the constructive form in which they are used in scientific work. The purpose of this lecture course is to make up this deficiency.

Lecture notes
Lecture notes and additional materials are available.

see Compulsory Elective Courses Teaching Diploma

Physics Teaching Diploma - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium |

ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1823 of 2345
This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.

**Core Courses in Theoretical Physics**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>402-0861-00L</td>
<td>Statistical Physics</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>E. Demler</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.</td>
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<td></td>
<td>This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.</td>
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<tr>
<td></td>
<td>Content</td>
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<td></td>
<td>Lecture notes</td>
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<td>Lecture notes available in English.</td>
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<tr>
<td>402-0843-00L</td>
<td>Quantum Field Theory I</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>R. Renner</td>
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<td>Abstract</td>
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<td>This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity. Topics include: - Relativistic quantum mechanics - Quantisation of bosonic and fermionic fields - Interactions in perturbation theory - Scattering processes and decays - Elementary processes in QED - Radiative corrections</td>
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<td>The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.</td>
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<td>Lecture notes</td>
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<td>Will be provided as the course progresses.</td>
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<td>Taught competencies</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>not assessed</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td></td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Social Competencies</td>
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<td>Personal Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>assessed</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<tr>
<td>402-0830-00L</td>
<td>General Relativity</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>L. Senatore</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.</td>
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<td>Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).</td>
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<td></td>
<td>Content</td>
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<td></td>
<td>Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.</td>
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</tbody>
</table>
### Literature

Suggested textbooks:

- C. Misner, K, Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

### Core Courses: Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0257-00L</td>
<td>Advanced Solid State Physics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>A. Zheludev</td>
</tr>
</tbody>
</table>

**Abstract**

This course is an extension of the introductory course on solid state physics.

The purpose of this course is to learn to navigate the complex collective quantum phases, excitations and phase transitions that are the dominant theme in modern solid state physics. The emphasis is on the main concepts and on specific experimental examples, both classic ones and those from recent research.

**Objective**

The goal is to study how novel phenomena emerge in the solid state.

**Content**

- Phase transitions and critical phenomena
- Main concepts: coherence length, symmetry, order parameter, correlation functions, generalized susceptibility
- Landau theory of phase transitions
- Fluctuations in Landau theory
- Critical exponents: significance, measurement, inequalities, equalities
- Scaling, hyperscaling and universality
- Quantum phase transitions and quantum criticality

- Fermi surface instabilities
  - The concept of the Landau Fermi liquid in metals
  - Kohn anomalies
  - Charge density waves
  - Metallic ferromagnets and half-metals
  - Spin density waves
  - Supercconductivity

- Magnetism of insulators
  - Magnetic interactions in solids and the spin Hamiltonian
  - Magnetic structures and phase transitions
  - Spin waves
  - Quantum magnetism

- Electron correlations in solids
  - Mott insulating state
  - Phases of the Hubbard model

**Lecture notes**

The printed material for this course involves: (1) a self-contained script, distributed electronically at semester start. (2) experimental examples (Power Point slide-style) selected from original publications, distributed at the start of every lecture.

**Literature**

A list of books will be distributed. Numerous references to useful published scientific papers will be provided.

### 402-0442-00L Quantum Optics

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>A. Imamoglu</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

**Objective**

The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

**Content**

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:

- coherence properties of light
- quantum nature of light: statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

**Lecture notes**

Selected book chapters will be distributed.

**Literature**

Textbooks:

- G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
- R. Loudon, The Quantum Theory of Light
- Atomic Physics, Christopher J. Foot
- Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
- Cohen-Tannoudji et al., Atom-Photon-Interactions
- M. Scully and M.S. Zubairy, Quantum Optics
- Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

### 402-0402-00L Ultrafast Laser Physics

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>L. P. Gallmann, S. Johnson, U. Keller</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.
Objective
Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.

Content
The lecture covers the following topics:

a) Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product

b) Dispersion compensation: technologies for controlling dispersion, pulse shaping, measurement of dispersion

c) Nonlinear pulse propagation: intensity-dependent refractive index (Kerr effect), self-phase modulation, nonlinear pulse compression, self-focusing, filamentation, nonlinear Schrödinger equation, solitons, non-instantaneous nonlinear effects (Raman/Brioullin), self-steepening, saturable gain and absorption

d) Second-order nonlinearities with ultrashort pulses: phase-matching with short pulses and real beams, quasi-phase matching, second-harmonic and sum-frequency generation, parametric amplification and generation

e) Relaxation oscillations: dynamical behavior of rate equations after perturbation

f) Q-switching: active Q-switching and its theory based on rate equations, active Q-switching technologies, passive Q-switching and theory

g) Active mode locking: introduction to mode locking, frequency comb versus axial modes, theory for various regimes of laser operation, Haus master equation formalism

h) Passive mode locking: slow, fast and ideally fast saturable absorbers, semiconductor saturable absorber mirror (SESAM), designs of and materials for SESAMs, mode locking with slow absorber and dynamic gain saturation, mode locking with ideally fast saturable absorber, Kerr-lens mode locking, soliton mode locking, Q-switching instabilities in mode locked lasers, inverse saturable absorption

i) Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more

j) Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection

k) Ultrafast measurements: pump-probe scheme, transient absorption/differential transmission spectroscopy, four-wave mixing, optical gating and more

l) Frequency combs and carrier-envelope offset phase: measurement and stabilization of carrier-envelope offset phase (CEP), time and frequency domain applications of CEP-stabilized sources

m) High-harmonic generation and attosecond science: non-perturbative nonlinear optics / strong-field phenomena, high-harmonic generation (HHG), phase-matching in HHG, attosecond pulse generation, attosecond technology: detectors and diagnostics, attosecond metrology (streaking, RABBITT, transient absorption, attoclock), example experiments

n) Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications

o) Brief introduction to other hot topics: relativistic and ultra-high intensity ultrafast science, ultrafast electron sources, free-electron lasers, etc.

Lecture notes
Class notes will be made available.

Prerequisites / notice
Prerequisites: Basic knowledge of quantum electronics (e.g., 402-0275-00L Quantenelektronik).

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
assessed

402-0891-00L Phenomenology of Particle Physics I
W 10 credits 3V+2U P. Crivelli, A. de Cosa

Objective
Topics to be covered in Phenomenology of Particle Physics I:
Relativistic kinematics
Decay rates and cross sections
The Dirac equation
From the S-matrix to the Feynman rules of QED
Scattering processes in QED
Experimental tests of QED
Hadron spectroscopy
Unitary symmetries and QCD
QCD and alpha_s running
QCD in e^+e^- annihilation
Experimental tests of QCD in e^+e^- annihilation

Content
Introduction to modern particle physics
Topics to be covered in Phenomenology of Particle Physics I:
Relativistic kinematics
Decay rates and cross sections
The Dirac equation
From the S-matrix to the Feynman rules of QED
Scattering processes in QED
Experimental tests of QED
Hadron spectroscopy
Unitary symmetries and QCD
QCD and alpha_s running
QCD in e^+e^- annihilation
Experimental tests of QCD in e^+e^- annihilation

Literature
As described in the entity: Lernmaterialien

Electives
Physics and Mathematics
Selection: Solid State Physics
There are numerous physical phenomena that rely on time-dependent Hamiltonians (or parametric driving) to amplify, cool, squeeze or couple resonating systems. In this course, we will introduce parametric phenomena in different fields of physics, ranging from manipulation of emergent quantum states observed to generate on solid-state systems, to quantum limited amplifiers, to optical frequency combs, and to optomechanical sensors used in the LIGO experiment. The course will combine theoretical lectures and the study of important experiments through literature.

The students will receive an extended lecture summary as well as numerous MATHEMATICA and Python scripts, including QuTiP notebooks. These tools will enable them to apply analytical and numerical methods to a wide range of systems beyond the duration of the course.

The lecture can also be followed by interested non-physics students as basic concepts will be introduced.

The students will understand both the theoretical foundations leading to the parametric drive as well as the experimental aspect related to the realizations of the effect. Each student will analyze an independent system using the tools acquired in the course and will present his/her insights to the class.

The students should be familiar with wave mechanics as well as second quantization. Following the course requires a laptop with Python and MATHEMATICA installed.

The lecture notes A full script will be available.

Literature

Prerequisites / notice

The lecture can also be followed by interested non-physics students as basic concepts will be introduced.

Learning material will be made available through a dedicated RStudioServer and through Moodle.

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.
The course covers the fundamentals of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k·p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots


The course is taught in English.

402-0317-00L Semiconductor Materials: Fundamentals and Fabrication

W
6 credits
2V+1U
S. Schön, W. Wegscheider

Abstract

This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objectives

Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

Content

1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 CZochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
   2.4 Semiconductor Epitaxy
   2.5 Fundamentals of Epitaxy
   2.6 Molecular Beam Epitaxy (MBE)
   2.7 Metal-Organic Chemical Vapor Deposition (MOCVD)
   2.8 Liquid Phase Epitaxy (LPE)
   2.9 In situ characterization
   2.10 Pressure and temperature
   2.11 Reflectometry
   2.12 Ellipsometry and RAS
   2.13 LEED, AES, XPS
   2.14 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes

https://moodle-app2.let.ethz.ch/course/view.php?id=

Prerequisites / notice

The "compulsory performance element" of this course is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

402-0447-00L Quantum Science with Superconducting Circuits

W
6 credits
2V+1U
A. Wallraff, J.-C. Besse, C. Hellings

Abstract

Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.
Objective

Based on today's most advanced solid state platform for quantum control, the students will learn how to engineer quantum coherent devices and how to use them to process quantum information. The students will acquire both analytical and numerical methods to model the properties and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.

Content


Prerequisites / notice

All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

C. Cohen-Tannoudji et al., Atom-Photon-Interactions (recommended)

Electronic states in III-V materials and quantum structures, optical transitions, excitons and polaritons, novel two dimensional

A. Imamoglu

Description of open quantum systems using master equation and quantum trajectories. Decoherence and quantum measurements. Dicke

This course presents a comprehensive discussion of optical processes in semiconductors.

Lecture notes will be provided

Advanced Topics in Quantum Optics

Number

Title

Type

ECTS

Hours

Lecturers

402-0442-05L

402-0444-00L

402-0457-00L

402-0464-00L

402-0465-58L

Content

The lecture will cover current topics and scientific papers in the wider field of quantum optics in an interactive format. First, the research area will be introduced, then several papers of this field will be presented by the students in the style of a journal club. Selected papers will be contrasted and their strengths and weaknesses discussed by the students in panel discussions. Furthermore, r

This course builds up on the material covered in the Quantum Optics course. The emphasis will be on quantum optics in condensed-matter systems.

The course aims to provide the knowledge necessary for pursuing advanced research in the field of Quantum Optics in condensed matter systems. Fundamental concepts and techniques of Quantum Optics will be linked to experimental research in systems such as quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

The aim of the lecture is to deepen and broaden the knowledge about current research in the field of quantum optics. In addition, it will also be discussed and critically examined how research results are communicated via publications and lectures and which techniques are used in the process.

We will select topical fields in quantum optics and quantum science and discuss recently published work.

Topics:
- Atoms or ions-based quantum computing
- Quantum simulation
- Opto-mechanics
- Driven and dissipative quantum systems
- Cavity based atom-light interaction
- Topological photonics

The interactive part of the lecture will include presentations of recent papers, panel discussions of recent papers and the writing of a critical assessment of an arXiv paper in the style of a referee report.

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- Quantum simulation
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- Driven and dissipative quantum systems
- Cavity based atom-light interaction
- Topological photonics

The interactive part of the lecture will include presentations of recent papers, panel discussions of recent papers and the writing of a critical assessment of an arXiv paper in the style of a referee report.
Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent tunability, this system can be seen as the “ultimate quantum designer’s material”.

The goal of this lecture is to explore both the rich physics as well as the application of these systems for sources and detectors. In fact, devices based on intersubband transitions are now unlocking large areas of the electromagnetic spectrum.

The lecture will treat the following chapters:
- Introduction: intersubband optoelectronics as an example of quantum engineering
- Technological aspects
- Electronic states in semiconductor quantum wells
- Intersubband absorption and scattering processes
- Mid-IR and THz ISB Detectors
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
  - Mid-IR QCLs
  - THz QCLs (direct and non-linear generation)
- Further electronic confinement: interlevel Qdot transitions and magnetic field effects
- Strong light-matter coupling in Mid-IR and THz range

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Mostly the original articles, other useful reading can be found in:
- E. Rosencher and B. Vinter, Optoelectronics, Cambridge Univ. Press
- G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press

Requirements: A basic knowledge of solid-state physics and of quantum electronics.

Experimental platforms based on Rydberg atoms is promising for implementing quantum technologies, including quantum nonlinear optics, quantum simulation, quantum computation and sensing. This course covers the basic properties of Rydberg atoms, the state-of-art experimental systems based on Rydberg atoms, and their variety applications for implementing quantum information science.

By the end of this course, students will be able to
- Learn the basic properties of Rydberg atoms and explain the advantages of using Rydberg atoms for quantum science.
- Learn several experimental schemes to build the state-of-art quantum hardware based on Rydberg atoms, including free-space approach, Rydberg atoms in an optical cavity, and programmable arrays of Rydberg atoms.
- Discuss several near-term applications in quantum information science, including how to use the arrays of Rydberg atoms to simulate quantum many-body systems and to perform quantum logic operations for quantum computation, how to facilitate precise control over individual photons with Rydberg atoms, and so on.

This course will focus on quantum science with Rydberg atoms. It aims to cover both theoretical and experimental aspects. Topics which will be covered include:
- A brief review of quantum technologies
- Properties of Rydberg atoms
- Quantum nonlinear optics with Rydberg atoms
  - Engineering photon-photon interactions with Rydberg polaritons in free space
  - Performing photonic quantum gate operations with Rydberg atoms in optical cavity systems
- Quantum simulation with arrays of Rydberg atoms
  - Simulating quantum spin models with arrays of Rydberg atoms (including the study on quantum phase transitions, quantum dynamics, and so on)
- Quantum computation with Rydberg atoms
  - Encoding qubits with atoms and performing quantum gate operations with Rydberg atoms
  - Start-of-art schemes for achieving general purpose quantum computation and current limitations
- Near-term applications in quantum optimizations

This course requires a good working knowledge in non-relativistic quantum mechanics. Prior knowledge of quantum optics is recommended but not required.
1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes
   Slides and book chapter will be available for downloading

Literature
   References will be given during the lecture

Prerequisites / notice
   Basics of solid-state physics (i.e. energy bands) can help

402-0484-00L  Experimental and Theoretical Aspects of Quantum Gases  W  6 credits  2V+1U  T. Esslinger

Abstract
   Quantum Gases are the most precisely controlled many-body systems in physics. This provides a unique interface between theory and experiment, which allows addressing fundamental concepts and long-standing questions. This course lays the foundation for the understanding of current research in this vibrant field.

Objective
   The lecture conveys a basic understanding for the current research on quantum gases. Emphasis will be put on the connection between theory and experimental observation. It will enable students to read and understand publications in this field.
Cooling and trapping of neutral atoms
Bose and Fermi gases
Ultracold collisions
The Bose-condensed state
Elementary excitations
Vortices
Superfluidity
Interference and Correlations
Optical lattices

Lecture notes
notes and material accompanying the lecture will be provided

Literature

◮◮◮ Selection: Particle Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0457-00L</td>
<td>Quantum Technologies for Searches of New Physics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Crivelli, D. Kienzler</td>
</tr>
</tbody>
</table>

Abstract
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

Objective
The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multidisciplinary field.

Content
The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics:
- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

Prerequisites / notice
The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

402-0715-00L Low Energy Particle Physics | W | 6 credits | 2V+1U | A. S. Antognini, P. A. Schmidt-Weilenburg

Abstract
Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrons, muons and exotic atoms.

Objective
You will be able to present and discuss:
- the principle of the experiments
- the underlying technique and methods
- the context and the impact of these experiments on particle physics

Content
Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics", making use of high precision and high intensities.

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrons and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:
- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spin manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling...
402-0767-00L  Neutrino Physics  W 6 credits 2V+1U  A. Rubbia, D. Sgalaberna

Abstract  Theoretical basis and selected experiments to determine the properties of neutrinos and their interactions (mass, spin, helicity, chirality, oscillations, interactions with leptons and quarks).

Objective  Introduction to the physics of neutrinos with special consideration of phenomena connected with neutrino masses.

Lecture notes  Script


D.O. Caldwell, Current Aspects of Neutrino Physics, Springer.

402-0725-00L  Experimental Methods and Instruments of Particle Physics  W 6 credits 3V+1U  U. Langenegger, T. Schietinger, University lecturers

Abstract  Physics and design of particle accelerators.
Basics and concepts of particle detectors.
Track- and vertex-detectors, calorimetry, particle identification.
Special applications like Cherenkov detectors, air showers, direct detection of dark matter.
Simulation methods, readout electronics, trigger and data acquisition.
Examples of key experiments.

Objective  Acquire an in-depth understanding and overview of the essential elements of experimental methods in particle physics, including accelerators and experiments.

Content  1. Examples of modern experiments
2. Basics: Bethe-Bloch, radiation length, nucl. interaction length, fixed-target vs. collider, principles of measurements: energy- and momentum-conservation, etc
3. Physics and layout of accelerators
4. Charged particle tracking and vertexing
5. Calorimetry
6. Particle identification
7. Analysis methods: invariant and missing mass, jet algorithms, b-tagging
8. Special detectors: extended airshower detectors and cryogenic detectors
9. MC simulations (GEANT), trigger, readout, electronics

Lecture notes  Slides are handed out regularly. See http://www.physik.uzh.ch/en/teaching/PHY461/

Taught competencies  Subject-specific Competencies Concepts and Theories assessed
Techniques and Technologies assessed

402-0777-00L  Particle Accelerator Physics and Modeling I  W 6 credits 2V+1U  A. Adelmann

Abstract  This is the first of two courses, introducing particle accelerators from a theoretical point of view and covers state-of-the-art modelling techniques.

Objective  You understand the building blocks of particle accelerators. Modern analysis tools allows you to model state-of-the-art particle accelerators. In some of the exercises you will be confronted with next generation machines. We will develop a Python (or Julia) simulation tool (pyAccCELEGOrator or jAcceLEGOrator) that reflects the theory from the lecture.

Content  - Recap of Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

Lecture notes  Lecture notes

Prerequisites / notice  Physics, Computational Science (RW) at BSc. Level

This lecture is also suited for PhD. students

402-0851-00L  QCD: Theory and Experiment  Does not take place this semester.

Special Students UZH must book the module PHY561 directly at UZH.

Abstract  An introduction to the theoretical aspects and experimental tests of QCD, with emphasis on perturbative QCD and related experiments at colliders.

Objective  Knowledge acquired on basics of perturbative QCD, both of theoretical and experimental nature. Ability to perform simple calculations of perturbative QCD, as well as to understand modern publications on theoretical and experimental aspects of perturbative QCD.

Content  QCD Lagrangian and Feynman Rules
QCD running coupling
Parton model
DGLAP
Basic processes
Experimental tests at lepton and hadron colliders
Measurements of the strong coupling constant
Advanced theoretical methods for analyzing quantum many-body systems will be reviewed. We will discuss equilibrium Green's functions, applications such as quantum cryptography and quantum coding theory.

By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.

Lecturers
J. Renes

Content
Mathematical formulation of quantum theory; entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory; distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

Lecture notes
Distributed via moodle.

Literature
Nielsen and Chuang, Quantum Information and Computation
Preskill, Lecture Notes on Quantum Computation
Wilde, Quantum Information Theory
Watrous, The Theory of Quantum Information

Introduction to the most important concepts of superconductivity both on phenomenological and microscopic level, including experimental and theoretical aspects.

Abstract
Superconductivity: thermodynamics, London and Pippard theory; Ginzburg-Landau theory; spontaneous symmetry breaking, flux quantization, type I and II superconductors; microscopic BCS theory: electron-phonon mechanism, Cooper pairing, quasiparticle spectrum, thermodynamics and response to magnetic fields. Josephson effect: superconducting quantum interference devices (SQUID) and other applications.

Objective
Introduction to the most important concepts of superconductivity both on phenomenological and microscopic level, including experimental and theoretical aspects.

Content
This lecture course provides an introduction to superconductivity, covering both experimental as well as theoretical aspects. The following topics are covered:

- Basic phenomena of superconductivity: thermodynamics, electrodynamics, London and Pippard theory; Ginzburg-Landau theory; spontaneous symmetry breaking, flux quantization, properties of type I and II superconductors; mixed phase, microscopic BCS theory; electron-phonon mechanism, Cooper pairing, coherent state, quasiparticle spectrum, thermodynamics and response to magnetic fields;
- Josephson effect, superconducting quantum interference devices (SQUID) and other applications.

Lecture notes
Lecture notes and additional materials are available.

Literature
M. Tinkham "Introduction to Superconductivity"
P. G. de Gennes "Superconductivity Of Metals And Alloys"
A. A. Abrikosov "Fundamentals of the Theory of Metals"
J.B. Ketterson & S.N. Song "Superconductivity"
H. Stolz "Supraleitung" (German)
K. Fossheim & A. Sudbo "Superconductivity: Physics and Applications"

Prerequisites / notice
The preceding attendance of the scheduled lecture courses "Introduction to Solid State Physics" and "Quantum Mechanics I" are mandatory. The lectures "Quantum Mechanics II" and "Solid State Theory" provide the most optimal conditions to follow this course.

Introduction to Advanced Methods in Quantum Many-Body Theory

Abstract
Advanced theoretical methods for analyzing quantum many-body systems will be reviewed. We will discuss equilibrium Green's functions, Keldysh formalism for nonequilibrium phenomena, variational approaches. Specific models that will be considered include systems with dissipation, polaron, interacting electrons, electron-phonon systems, transport in mesoscopic systems, superconductivity, cavity QED

Objective
Introduce advanced theoretical methods for analyzing quantum many-body systems including Green's functions and variational approaches.

Prerequisites / notice
This class assumes familiarity with quantum mechanics, including second quantization, and condensed matter physics.

Introduction to Computational Physics

Abstract
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and supercomputers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

Objective
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem. Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Lecture notes
Lecture notes and slides are available online and will be distributed if desired.

Literature
Lecture notes and slides are available online and will be distributed if desired.

Prerequisites / notice
Lecture and exercise lessons in english, exams in German or in English

Programming Techniques for Scientific Simulations

Abstract
This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputers, optimization methods for scientific simulation codes are explained.

Objective
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

Effective Field Theories for Particle Physics

Abstract
Special Students UZH must book the module PHY578

Objective
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.
Abstract
The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. These topics will be discussed both in general terms and with specific phenomenological applications in the context of physics beyond the Standard Model, effective description of the weak interaction, as well as the description of non-perturbative strong interaction at low energies.

Objective
This course covers the basic concepts of effective field theories (EFTs) and dispersion theory. We will start by introducing the core concept of constructing EFTs and apply them to the low-energy description of the weak interaction and the effective description of heavy physics beyond the Standard Model.

In the next part of the course, we will discuss Chiral Perturbation Theory (ChPT), the low-energy effective theory of Quantum Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

Content
- Introduction to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

Prerequisites / notice
QFT-I (mandatory) and QFT-II (highly recommended)
Quantum Chromodynamics  

**Prerequisites / notice**  
A basic knowledge of Feynman rules in scalar field theories and in Yang-Mills theory is assumed.  
QFT-I, QFT-II and Introduction to Quantum ChromoDynamics are highly recommended.

**402-0886-00L**  
Quantum Chromodynamics  
W 6 credits 2V+1U  
T. K. Gehrmann

* Does not take place this semester.  
* Special Students UZH must book the module PHY564 directly at UZH.

**Abstract**  
The course presents the quantum field theory of the strong interaction (quantum chromodynamics, QCD) and discusses its applications to particle physics observables.

**Objective**  
The course aims to familiarize its students with the concepts and applications of QCD and to introduce them to modern techniques for computations in QCD.

**Content**  
- Review of non-Abelian gauge theories and their quantization  
- Spinor-helicity formalism  
- Renormalization of QCD and running coupling constant  
- Basic strong interaction processes  
- Perturbation theory techniques: loops and phase space  
- QCD perturbation theory and applications  
- Proton structure in QCD  
- Resummation of large logarithmic corrections  
- Effective field theories  
- Non-perturbative methods

**Prerequisites / notice**  
The course assumes prior knowledge of the content of the quantum field theory 1+2 lectures.

Introduction to String Theory  

**402-0897-00L**  
Introduction to String Theory  
W 6 credits 2V+1U

* Does not take place this semester.

**Abstract**  
String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

**Objective**  
Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

**Content**  
- mechanics of point particles and extended objects  
- string modes and their quantisation; higher dimensions, supersymmetry  
- D-branes, T-duality  
- supergravity as a low-energy effective theory, strings on curved backgrounds  
- two-dimensional field theories (classical/quantum, conformal/non-conformal)

**Literature**  

**Prerequisites / notice**  
Recommended: Quantum Field Theory I (in parallel)

Higgs Physics  

**402-0899-65L**  
Higgs Physics  
W 6 credits 2V+1U  
M. Donegà, M. Grazzini

* Special Students UZH must book the module PHY567 directly at UZH.

**Abstract**  
This year we celebrate the tenth anniversary of the discovery of the Higgs boson. With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background and learn about the main experimental methods used to study the physics the Higgs boson.

**Objective**  
With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background to understand the main production and decay channels of the Higgs boson at high-energy colliders, and the corresponding experimental signatures.

**Content**  
**Theory part:**  
- the Standard Model and the mass problem: WW scattering and the no-lose theorem  
- the Higgs mechanism and its implementation in the Standard Model  
- radiative corrections and the screening theorem  
- theoretical constraints on the Higgs mass; the hierarchy problem  
- Higgs production in e+e- collisions  
- Higgs production at hadron colliders  
- Higgs decays to fermions and vector bosons  
- Higgs differential distributions, rapidity distribution, pt spectrum and jet vetoes  
- Higgs properties and beyond the Standard Model perspective  
- Outlook: The Higgs sector in weakly coupled and strongly coupled new physics scenarios.

**Experimental part:**  
**Introductory material:**  
- basics of accelerators and detectors  
- reminders of statistics: likelihoods, hypothesis testing  
- reminders of multivariate techniques: Boosted Decision Trees and Neural Networks

**Main topics:**  
- pre-history (pre-LEP)  
- LEP1: measurements at the Z-pole  
- Electroweak constraints  
- LEP2: towards the limit mH<114 GeV  
- TeVatron searches  
- LHC:  
  -- main channels overview  
  -- dissect one analysis  
  -- combine information from all channels  
  -- differential measurements  
  -- off-shell measurements
The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most
Lecture notes and additional materials are available.

2V+1U

The course shall provide a basic understanding of the potential and limitation of different types of modern astronomical observations for
The course covers the quantum Hall effect from various perspectives (phenomenology, heuristic explanation, role of disorder, Landau
The course will cover

G. M. Graf

This course provides a pedagogical introduction to Quantum Electrodynamics.

1. Introduction: research projects in astronomical observations

2. Observables: electromagnetic radiation, particles
3. Optical telescopes: Optics, types, mechanical concepts, examples
4. Detectors: CCDs, IR detectors, basic data reduction steps
5. Photometry: signal extraction, calibration, faint sources, etc.
6. Spectroscopy: spectrographs, calibration, spectral features
7. Introduction to solar space instrumentation
8. Space observations of cosmic dust: introduction, remote sensing, in situ instruments, sample return, calibration, data analysis and practical examples
9. Speckles and adaptive optics: atmosphere, AO-systems
10. Interferometry: measuring principles
11. Interferometry

- Anomalous magnetic moments
- Infinities and Renormalization
- Amplitudes and cross sections for simple processes in QED

Prerequisites / notice
Prerequisites: Quantum Field Theory I, Phenomenology of Particle Physics I

402-0875-65L
Topological Aspects of Condensed Matter Physics

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>4</td>
<td>G. M. Graf</td>
</tr>
</tbody>
</table>

Abstract
The course covers the quantum Hall effect from various perspectives (phenomenology, heuristic explanation, role of disorder, Landau
Hamiltonian, Kubo formula, Chern numbers, index of a pair of projections, bulk and edge). Also discussed: Topological insulators and their
indices; the Kitaev table; fibre bundles (mathematical digression).

Content
The course covers the quantum Hall effect from various perspectives (phenomenology, heuristic explanation, role of disorder, Landau
Hamiltonian, Kubo formula, Chern numbers, index of a pair of projections, bulk and edge). Also discussed: Topological insulators and their
indices; the Kitaev table; fibre bundles (mathematical digression).

402-0869-00L
Qualitative Methods in Physics

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>6</td>
<td>V. Geshkenbein</td>
</tr>
</tbody>
</table>

Abstract
We will discuss, how qualitative thinking allows to progress in different areas of physics, from classical to quantum mechanics, from phase
transitions, to developed turbulence and Anderson localisation.

Objective
The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most
attractive and beautiful characteristic of this discipline. However, as experience shows, it is just these aspects which are most difficult for
beginner. Unfortunately, the methods of theoretical physics are usually presented in a formal, mathematical way, rather than in the
constructive form in which they are used in scientific work. The purpose of this lecture course is to make up this deficiency.

Lecture notes
Lecture notes and additional materials are available.

402-0870-00L
Introduction to Quantum Electrodynamics

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>6</td>
<td>V. Geshkenbein</td>
</tr>
</tbody>
</table>

Abstract
This course provides a pedagogical introduction to Quantum Electrodynamics.

Objective
Students will be introduced to the theory of Quantum Electrodynamics, and to using Feynman diagrams to arrive at theoretical predictions
for phenomena related to the interaction of light and matter. The course is designed to complement Quantum Field Theory I for those
students with a special interest in elementary particle physics.

Content
The course will cover

- an introduction to QED as the quantum theory of interactions of light and matter.
- Feynman rules for QED
- An introduction to helicity and spinors
- Amplitudes and cross sections for simple processes in QED
- Infinites and Renormalization
- The Hydrogen atom
- The Lamb shift
- Anomalous magnetic moments

Lecture notes
Lecture notes and additional materials are available.

Literature
Will be provided at the Moodle site for the course.

Literature
Will be provided at the Moodle site for the course.

Selection: Astrophysics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0352-00L</td>
<td>Astronomical Observations and Instrumentation</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>H. M. Schmid, L. Harra</td>
</tr>
</tbody>
</table>

Abstract
Astronomical techniques and observing strategies are presented with a particular emphasis on currently available professional telescopes
of the European Southern Observatory.

Objective
The course shall provide a basic understanding of the potential and limitation of different types of modern astronomical observations for
early career researchers. The course will present technical aspects which are important to prepare, to carry out and to calibrate different
types of astronomical measurements: photometry, spectroscopy, astrometry, polarimetry and others. Many practical examples will be
discussed, including methods for the detection of physical samples of cosmic dust. Also scientific aspects of instrumental projects and
observational programs are addressed. An opportunity to contribute to solar spacecraft operations will be available during the course.

Content
1. Introduction: research projects in astronomical observations
2. Observables: electromagnetic radiation, particles
3. Optical telescopes: Optics, types, mechanical concepts, examples
4. Detectors: CCDs, IR detectors, basic data reduction steps
5. Photometry: signal extraction, calibration, faint sources, etc.
6. Spectroscopy: spectrographs, calibration, spectral features
7. Introduction to solar space instrumentation
8. Space observations of cosmic dust: introduction, remote sensing, in situ instruments, sample return, calibration, data analysis and practical examples
9. Speckles and adaptive optics: atmosphere, AO-systems
10. Imaging interferometry: measuring principles
11. Interferometry

Lecture notes
Notes will be distributed.

Literature
This course reviews the formation processes of terrestrial- and gaseous planets, and their moons. It provides a basic understanding on how our Solar System came to be, and how other planetary systems form, as well as how/when planets & moons can be habitable places for life.

Objective
Overview the state of the art planet- and moon formation models and identify open questions in the field. Understanding the formation process of planetary systems, and the formation of habitable worlds.

Content
1) Planet types
2) The Solar System planets
3) Extrasolar Planets
4) The protoplanetary disk where planets are forming. The initial conditions for planet formation.
5) The formation of the building blocks of planets (so-called “planetesimals”)
6) Terrestrial Planet formation
7) Formation models of giant planets
8) Formation of moons
9) Evolution of planetary systems, orbital evolution of planets, resonances, planet-disk interactions
10) Origin of life, habitability, astrobiology

Literature
Astrophysics of Planet Formation
Armagh, Philip J. : Second edition – 2020
https://eth.swisscovery.sisp.ch/permalink/41SLSP_ETH/lshl64/alma99117212978705503

Prerequisites / notice
No prerequisites.
Max. 20 participants.

402-0368-70L Lecture Series: Space Research and Exploration W 1 credit 2V S. P. Quanz

Abstract
Lecture Series about topics of space research and exploration consisting of individual talks given by different leading experts from industry and academia.

Objective
Attending students will
- experience the interdisciplinary space research and exploration spanning physics, engineering, geosciences, biology and more
- get familiar with the Swiss space research and industry sector
- improve their report writing skills by reflecting on one of the talks
- enhance their communication skills by broadening their research horizon
- have the opportunity for direct learning by posing questions to experts

Content
The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The ‘Lecture Series: Space Research and Exploration’ aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lecture, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.

(List of speakers will be made available in due time)
Objective
Cosmic dust is an important building block for planets and towards life. This course provides students with a basic understanding of the science of cosmic dust in the solar system, and how to measure it with space-based satellites and instrumentation. The lectures include the physical processes of both interplanetary and interstellar dust, trajectory simulations (i.e. orbital dynamics), in situ measurement techniques, and mission design aspects. At the end of the course, students are able to classify the different types of dust in the solar system, and to relate them to their sources, sinks, their importance for planetary science and astronomy, physical processes, and appropriate measurement techniques. They will be able to simulate dust trajectories and use them to gain insight in how orbital dynamics and the space environment shape them. Students can design a basic concept of a space mission for dust measurements. The skills taught in this course will be useful to students in a broader way for planetary sciences.

Content
1. Introduction, course outline, historical notes, interstellar and interplanetary dust, dust in the solar system, sources, sinks, importance for science
2. Dust instrumentation and observables: ground-based, space-based and sample return techniques, calibration of dust instruments in the lab
3. Dust dynamics: recap basic aspects of orbital dynamics, the SPICE toolkit, types of orbits
4. Dust dynamics: space environment, dust processes and implications (e.g. in the early solar system), dust charging, consequences for dynamics, comparison with spacecraft dynamics
5. Dust models and dust data analysis: types of models and their limitations, data analysis
6. Mission design aspects: orbits, mission design limitations, advantages, disadvantages, instrument accommodation, example missions

Lecture notes
Slides will be provided before each lecture.

Literature
Interplanetary dust (freely available online)
https://link.springer.com/book/10.1007/978-3-642-56428-4

Prerequisites / notice
The exercise solutions are performed in the Julia programming language.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0713-00L</td>
<td>Astro-Particle Physics I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>A. Biland</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture gives an overview of the present research in the field of Astro-Particle Physics, including the different experimental techniques. In the first semester, main topics are the charged cosmic rays including the antimatter problem. The second semester focuses on the neutral components of the cosmic rays as well as on some aspects of Dark Matter.</td>
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<td>Objective</td>
<td>Successful students know:</td>
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<td>- experimental methods to measure cosmic ray particles over full energy range</td>
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<td>- current knowledge about the composition of cosmic ray</td>
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<td>- possible cosmic acceleration mechanisms</td>
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<td>- correlation between astronomical object classes and cosmic accelerators</td>
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<td>- information about our galaxy and cosmology gained from observations of cosmic ray</td>
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<tr>
<td>Content</td>
<td>First semester (Astro-Particle Physics I):</td>
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<td>- definition of 'Astro-Particle Physics'</td>
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<td>- important historical experiments</td>
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<td>- chemical composition of the cosmic rays</td>
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<td>- direct observations of cosmic rays</td>
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<td>- indirect observations of cosmic rays</td>
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<td></td>
<td>- 'extended air showers' and 'cosmic muons'</td>
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<td></td>
<td>- 'knee' and 'ankle' in the energy spectrum</td>
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<td></td>
<td>- the 'anti-matter problem' and the Big Bang</td>
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<td></td>
<td>- 'cosmic accelerators'</td>
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<tr>
<td>Lecture notes</td>
<td>See lecture home page: <a href="http://ihp-hx2.ethz.ch/AstroTeilchen/">http://ihp-hx2.ethz.ch/AstroTeilchen/</a></td>
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<tr>
<td>Literature</td>
<td>See lecture home page: <a href="http://ihp-hx2.ethz.ch/AstroTeilchen/">http://ihp-hx2.ethz.ch/AstroTeilchen/</a></td>
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| 402-0395-10L  | Black Holes and Gravitational Waves              | W    | 8    | 4G     | L. Heisenberg, F. D'Ambrosio, A. Giusti |
| Abstract      | The course will discuss some hot topics in gravitational physics, providing an overview on the necessary formalism and its applications to black hole physics and gravitational waves. |
| Objective     | The course aims at providing a general introduction to the necessary tools needed to approach two very active research topics in gravitational physics: 1) theoretical black hole physics; 2) gravitational waves. Time permitting, more formal concepts like the initial value problem in general relativity and quasi-local notions of horizon will be discussed. The course will include a brief introduction to general relativity and differential geometry. |
| Contents:     | 1. Brief introduction to Differential Geometry and General Relativity; |
|               | 2. Elementary black hole solutions in general relativity and their properties; |
|               | 3. Conserved charges; |
|               | 4. Geometry of hypersurfaces and horizons; |
|               | 5. Singularity theorems; |
|               | 6. Hawking radiation and the information loss paradox; |
|               | 7. Generalities on gravitational waves; |
|               | 8. Phenomenology of black hole mergers |
| Lecture notes | Lecture notes and/or slides will be made available prior to each lecture. |
|               | N. Straumann, General Relativity, (Springer, 2013) |
|               | P. Jetzer, Applications of General Relativity, (Springer, 2022) |

Selection: Further Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
<tr>
<td>Abstract</td>
<td>Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts. How much energy do we need and can it be provided in a way that allows for sustainable existence?</td>
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</tbody>
</table>
1. Introduction to Energy – what is it all about

As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasing their need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling.

Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly be taught in small groups to the above themes complement the lectures. Learning how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be used to apply the concepts learned during the lectures to solve exercises.

As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasing their need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling.

Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

Critical Thinking

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1840 of 2345
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on the properties of nerves that are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of mono- and poly-cultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to solving mysteries of neural computation. The goal of this introductory course is to introduce the students to the conception, simulation, and physical layout of neuromorphic circuits. The course teaches the conception, simulation, and physical layout of such circuits with chip design tools.

### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
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<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
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<td>Sensitivity to Diversity</td>
<td>Self-direction and Self-management</td>
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### Selection: Neuroinformatics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu</td>
</tr>
</tbody>
</table>

**Abstract**

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**

Understanding of the characteristics of neuromorphic circuit elements.

**Content**

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on the properties of nerves that are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of mono- and poly-cultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to solving mysteries of neural computation. The goal of this introductory course is to introduce the students to the conception, simulation, and physical layout of such circuits with chip design tools.

### Selection: Medical Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>2+1U+1A</td>
<td>V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens</td>
</tr>
</tbody>
</table>

**Abstract**

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

**Objective**

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the students to the conception, simulation, and physical layout of such circuits with chip design tools.

**Content**

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of mono- and poly-cultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.
### 402-0341-00L Medical Physics I

**Abstract**

Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.

**Objective**

Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

**Content**

The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linearaccelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

**Lecture notes**

A script will be provided.

**Prerequisites / notice**

For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

### 402-0674-00L Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For Physical and chemical principles:

2V+1U

ECTS

W

Aerosols I: Physical and Chemical Principles

**Abstract**

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

**Objective**

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violent to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

### Selection: Environmental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1239-00L</td>
<td>Aerosols I: Physical and Chemical Principles</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>M. Gysel Beer, D. Bell, E. Weingartner</td>
</tr>
</tbody>
</table>

**Abstract**

Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

**Objective**

Physical and chemical principles:

- The students... - know the processes and physical laws of aerosol dynamics.
- understand the thermodynamics of phase equilibria and chemical equilibria.
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:

- The students... - know the most important chemical and physical measurement instruments.
- understand the underlying chemistry and physics.

Environmental impacts:

- The students... - know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- know the most important climate impacts of atmospheric aerosols.
- are aware of the health impacts of atmospheric aerosols.

**Lecture notes**

matériel is distributed during the lecture
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.

Students are able
- to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Dynamics of large-scale atmospheric flow

Boundary Layer Meteorology

The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes available (i.e. in English)


Prerequisites / notice
- Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Selection: Mathematics

Differential Geometry I

At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory
can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.


Abstract

Objective

Introduce the classical theory of curves and surfaces (which is the precursor of modern Riemannian geometry). Invite students to use and sharpen their geometric intuition.

Lecture notes

Partial lecture notes are available from Prof. Lang's website https://people.math.ethz.ch/~lang/

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- John M. Lee: Introduction to Smooth Manifolds
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie. Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Functional Analysis I

At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory
can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles; Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alosgu; reflexive spaces; compact operators and Fredholm theory; closed range theorem; spectral theory of self-adjoint operators in Hilbert spaces.

Abstract

Objective

Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.
Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and $L^p$ spaces).

401-3601-00L Probability Theory

- At most one of the three course units (Bachelor Core Courses)
- 401-3461-00L Functional Analysis I
- 401-3531-00L Differential Geometry I
- 401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studienreferat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Bachelor Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Abstract: Basics of probability theory and the theory of stochastic processes in discrete time

Objective: This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content: This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes: will be available in electronic form.

Pre-requisites / notice: Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and $L^p$ spaces).

401-3621-00L Fundamentals of Mathematical Statistics

- The course covers the basics of inferential statistics.

401-7851-00L Theoretical Astrophysics (University of Zurich)

- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- UZH Module Code: AST512

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Abstract: This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content: This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Literature: Course Materials:
- 1- The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
- 2- The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
- 3- Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
- 4- Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
- 5- Galactic Dynamics, James Binney and Scott Tremaine

选修课程：在苏黎世大学

UZH的讲师明确推荐以下课程，也推荐物理系的本科生参加。

关于UZH的学分计算，有兴趣的物理系本科生可以登录到UZH的教务处注册。

选修课程：在苏黎世大学

University of Zurich lecturers explicitly recommended the following courses also to physics students at ETH Zurich. Recognition of the corresponding external ECTS credits has to be granted by the Director of Studies. Submit your request to the Study Administration Office (www.math.ethz.ch/studienreferat) after having received the credits.

Submit your request to the Study Administration Office (www.math.ethz.ch/studienreferat) after having received the credits.

Submit your request to the Study Administration Office (www.math.ethz.ch/studienreferat) after having received the credits.

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Submit your request to the Study Administration Office (www.math.ethz.ch/studienreferat) after having received the credits.
Prerequisites / notice

This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

Prerequisites:
Introduction to Astrophysics
Mathematical Methods for the Physicist
Quantum Mechanics
(All preferred but not obligatory)

Prior Knowledge:
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-7855-00L</td>
<td>Computational Astrophysics (University of Zurich)</td>
<td>6</td>
<td>2V</td>
<td>L. M. Mayer</td>
</tr>
<tr>
<td>402-6394-00L</td>
<td>Advanced Topics of Theoretical Cosmology (University of Zurich)</td>
<td>4</td>
<td>1V</td>
<td>J. Yoo</td>
</tr>
<tr>
<td>402-0831-67L</td>
<td>Advanced Topics of General Relativity and Gravitational Waves (University of Zurich)</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Jetzer</td>
</tr>
</tbody>
</table>

401-7855-00L Computational Astrophysics (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: AST245

Mind the enrolment deadlines at UZH:

Objective
Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes.

Content
1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

Literature
Galactic Dynamics (Binney & Tremaine, Princeton University Press),
Computer Simulation using Particles (Hockney & Eastwood CRC press),
Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

402-6394-00L Advanced Topics of Theoretical Cosmology

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: AST802

Mind the enrolment deadlines at UZH:

Abstract
Following the core course Physical Cosmology (formerly theoretical cosmology), we study more advanced topics in theoretical cosmology. The lectures are given at the University of Zurich from 29 August 2022 until 9 September 2022 (two weeks) two hours everyday. No final exam.

Content
The topics in the course are as follows:
- spherical collapse model, Press-Schechter formalism, applications
- Standard Newtonian and Lagrangian Perturbation Theory
- galaxy bias
- nonlinear relativistic dynamics: ADM formalism
- inflationary models, effective field theory
- modification of gravity
- weak gravitational lensing, CMB anisotropies

Prerequisites / notice
Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial.

402-0831-67L Advanced Topics of General Relativity and Gravitational Waves (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: PHY529

Mind the enrolment deadlines at UZH:

Abstract
The aim of this lecture is to discuss some advanced topics in general relativity, which are useful to understand the present research activities in the field. A list of possible topics is given below. A basic knowledge of general relativity is required (ideally having followed the lecture on General Relativity). The course is particularly suited for master and PhD students.

Objective
Is to be able to read and understand the original literature and the presently published papers in the field of the discussed advanced topics. This might be also useful in view of doing afterwards a master thesis in the field of general relativity.

Content
Possible content:
- General relativistic stellar structure equations (Neutron stars)
- Tetrad formalism
- Spinors in GR
- Klein-Gordon & Dirac eqs. in GR
- Thermodynamics of black holes and Hawking radiation
- Topics in gravitational waves: GW generation by PN sources, GW from elliptic, hyperbolic binaries
- Tests of the equivalence principle
**General Electives**

Students may choose General Electives from the entire course programme of ETH Zurich - with the following restrictions: courses that belong to the first or second year of a Bachelor curriculum at ETH Zurich as well as courses from GESS "Science in Perspective" are not eligible here. The following courses are explicitly recommended to physics students by their lecturers. (Courses in this list may be assigned to the category “General Electives” directly in myStudies. For the category assignment of other eligible courses keep the choice “no category” and take contact with the Study Administration (www.phys.ethz.ch/studies/study-administration.html) after having received the credits.)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Steinfeld, E. I. M. Casati</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td>Lecture Notes containing copies of the presented slides.</td>
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<tr>
<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.</td>
</tr>
<tr>
<td>151-0163-00L</td>
<td>Nuclear Energy Conversion</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>A. Manera</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding</td>
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<td><strong>Objective</strong></td>
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<td>Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology.</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<td>Hand-outs will be distributed. Additional literature and information on the website of the lab: <a href="https://www.ethz.ch/content/specialinterest/avm/energy-technology/lab-of-nuclear-energy-systems/en/teaching-materials/151-0163-00l-nuclear-energy-conversion.html">https://www.ethz.ch/content/specialinterest/avm/energy-technology/lab-of-nuclear-energy-systems/en/teaching-materials/151-0163-00l-nuclear-energy-conversion.html</a></td>
</tr>
<tr>
<td></td>
<td><strong>R. L. Murray</strong>: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier</td>
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<tr>
<td>151-0103-00L</td>
<td>Fluid Dynamics II</td>
<td>W</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Jenny</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Expand basic knowledge of fluid dynamics.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>Concepts, phenomena and quantitative description of irrotational (potential), rotational, and one-dimensional compressible flows.</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
<td></td>
<td></td>
<td></td>
<td>Lecture notes are available (in German).</td>
</tr>
<tr>
<td></td>
<td><strong>Literature</strong></td>
<td></td>
<td></td>
<td></td>
<td>Relevant chapters (corresponding to lecture notes) from the textbook</td>
</tr>
<tr>
<td></td>
<td><strong>Prerequisites / notice</strong></td>
<td></td>
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<td></td>
<td>Analysis I/II, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas</td>
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<tr>
<td>151-0532-00L</td>
<td>Nonlinear Dynamics and Chaos I</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>G. Haller</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.</td>
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<td>(2) Near equilibrium dynamics: Linear and Lyapunov stability</td>
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<td>(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations</td>
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<td>(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.</td>
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<td>(5) Time-dependent dynamical systems: Floquet theory. Poincare maps, averaging methods, resonance</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<td>The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>- Prerequisites: Analysis, linear algebra and a basic course in differential equations.</td>
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<td>- Exam: two-hour written exam in English.</td>
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<td>- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.</td>
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<tr>
<td>151-0620-00L</td>
<td>Embedded MEMS Lab</td>
<td>W</td>
<td>5</td>
<td>3P</td>
<td>C. Hierold, M. Haluska</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1847 of 2345
Abstract
Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carrying out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access

Objective
Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

Content
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Lecture notes
A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

Prerequisites / notice
Participating students are required to attend all scheduled lectures and meetings of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"
Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Kourmoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

The course is offered in autumn and spring semester.

151-0213-00L Fluid Dynamics with the Lattice Boltzmann Method
W 4 credits 3G I. Karlin

Abstract
The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
Content

The course builds upon three parts:
I. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II. Theoretical basis of statistical mechanics and kinetic equations.
III. Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: Lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows;
   Numerical stability and accuracy.

5. Microflow:
   Rarefication effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LBM for fluid dynamics simulations:
   Relativistic fluid dynamics; flows with phase transitions.

Lecture notes

Lecture notes on the theoretical parts of the course will be made available.

Selected original and review papers are provided for some of the lectures on advanced topics.

Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice

The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0107-20L High Performance Computing for Science and Engineering (HPCSE) I

Abstract

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

Objective

With manufacturing processes reaching its limits in terms of transistor density on today's computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the "think parallel" mind-set of developers is still lagging behind.

Content

1. Hardware and Architecture: Moore's Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn's taxonomy. Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl's Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes

https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/

Literature

• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
• Lecture notes

Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

151-0621-00L Microsystems I: Process Technology and Integration

Abstract

Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).

Objective

Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).

Content

- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.
- Application of selected technologies will be demonstrated on case studies.

Lecture notes

Handouts (available online)
Literature
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice
Prerequisites: Physics I and II

227-0385-10L Biomedical Imaging
W 6 credits 5G S. Kozerke, K. P. Prüsmann

Abstract
Introduction and analysis of medical imaging technology including X-ray procedures, computed tomography, nuclear imaging techniques using single photon and positron emission tomography, magnetic resonance imaging and ultrasound imaging techniques.

Objective
To understand the physical and technical principles underlying X-ray imaging, computed tomography, single photon and positron emission tomography, magnetic resonance imaging, ultrasound and Doppler imaging techniques. The mathematical framework is developed to describe image encoding/decoding, point-spread function/modular transfer function, signal-to-noise ratio, contrast behavior for each of the methods. Matlab exercises are used to implement and study basic concepts.

Content
- X-ray imaging
- Computed tomography
- Single photon emission tomography
- Positron emission tomography
- Magnetic resonance imaging
- Ultrasound/Doppler imaging

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Prerequisites / notice
Analysis, Linear Algebra, Physics, Basics of Signal Theory, Basic skills in Matlab programming

227-0386-00L Biomedical Engineering
W 4 credits 3G J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content
- History of BME and the role of biomedical engineers. Ethical issues related to BME
- Biomedical sensors both wearable and also biochemical sensors
- Bioelectronics: Nerst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices
- Bioinformatics: genomic and proteomic tools, databases and basic calculations
- Equations describing basic reactions and enzyme kinetics
- Medical optics: Optical components and systems used in hospitals
- Basic concepts of tissue engineering and organ printing
- Biomedical sensors and their medical applications
- Function of the heart and the circulatory system
- Transport and exchange of substances in the human body, compartment modeling
- The respiratory system
- Bioimaging
- Orthopedic biomechanics
- Lectures (2h), discussion of practical exercises (1h) and homework exercises

Lecture notes
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino
AND moodle page of the course

Prerequisites / notice
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

227-1047-00L Consciousness: From Philosophy to Neuroscience
W 3 credits 2V D. Kiper

Abstract
Introduction into selected topics of consciousness and the relationship with physics and physiology. The focus is on learning the basic vocabulary of consciousness and getting familiar with concepts that govern common mental processes and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of consciousness and the relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the consciousness master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of consciousness are also outlined.

Content
- Subject-specific Competencies
  Concepts and Theories assessed
  Techniques and Technologies assessed

- Method-specific Competencies
  Analytical Competencies assessed
  Decision-making assessed
  Media and Digital Technologies not assessed
  Problem-solving not assessed
  Project Management not assessed

- Social Competencies
  Communication not assessed
  Cooperation and Teamwork not assessed
  Customer Orientation not assessed
  Leadership and Responsibility not assessed
  Self-presentation and Social Influence not assessed
  Sensitivity to Diversity not assessed
  Negotiation not assessed

- Personal Competencies
  Adaptability and Flexibility not assessed
  Creative Thinking not assessed
  Critical Thinking not assessed
  Integrity and Work Ethics not assessed
  Self-awareness and Self-reflection not assessed
  Self-direction and Self-management not assessed
(University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: INI410

Mind the enrolment deadlines at UZH:

Abstract
This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained. Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

Objective
The course's goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought by modern cognitive neuroscience. We aim to clarify concepts, explain their philosophical and scientific backgrounds, and to present experimental protocols that shed light on a variety of consciousness related issues.

Content
The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of consciousness, and proposals for the neural correlate of consciousness (NCC).

Lecture notes
None

Literature
We display articles pertaining to the issues we cover in the class on the course's webpage.

Prerequisites / notice
Since we are all experts on consciousness, we expect active participation and discussions!

<table>
<thead>
<tr>
<th>227-0939-00L Cell Biophysics</th>
<th>W 6 credits</th>
<th>4G</th>
<th>T. Zambelli</th>
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</thead>
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Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content
- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development; Turing patterns
- Sequences and evolution

Lecture notes
Theory and corresponding exercises are merged together during the classes.

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

Literature

Prerequisites / notice
Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Nonlinear Optics

W 6 credits 2V+2U J. Leuthold

Abstract
Nonlinear Optics deals with the interaction of light with material, the response of material to light and the mathematical framework to describe the phenomena. As an example we will cover fundamental phenomena such as the refractive index, the electro-optic effect, second harmonic generation, four-wave mixing or soliton propagation and others.

Objective
The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematical by means of the susceptibility.

Content
Chapter 1: The Wave Equations in Nonlinear Optics
Chapter 2: Nonlinear Effects - An Overview
Chapter 3: The Nonlinear Optical Susceptibility
Chapter 4: Second Harmonic Generation
Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator
Chapter 6: Acousto-Optic Effect
Chapter 7: Nonlinear Effects of Third Order
Chapter 8: Nonlinear Effects in Media with Gain

Literature
Lecture notes are distributed. For students enrolled in the course, additional information, lecture notes and exercises can be found on moodle (https://moodle-app2.let.ethz.ch/).

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics

Neural Network Theory

W 4 credits 2V+1U H. Bölcskei

Abstract
The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective
After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

Content
1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Lecture notes
Detailed lecture notes are available on the course web page https://www.mins.ee.ethz.ch/teaching/int/

Prerequisites / notice
This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

Electromagnetic Precision Measurements and Opto-Mechanics

W 4 credits 2V+1U M. Frimmer

Abstract
The measurement process is at the heart of both science and engineering. Electromagnetic fields have proven to be particularly powerful probes. This course provides the basic knowledge necessary to understand current state-of-the-art optomechanical measurement systems operating at the precision limits set by the laws of quantum mechanics.

Objective
The goal of this course is to understand the fundamental limitations of measurement systems relying on electromagnetic fields.

Content
The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics.
VLSI 3: Full-Custom Digital Circuit Design

(ABS-3G)

Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

F. Marone Welford

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course covers the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

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Semiconductor Devices: Physical Bases and Simulation

W 4 credits 3G C. I. Roman

The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

The course aims at understanding the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

The topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

The script (in book style) is sufficient. Further reading will be recommended in the lecture.


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Nano-Optics

W 6 credits 2V+2U M. Frimmer

Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

The course starts with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

- Electromagnetic fields and waves (or equivalent)
- Physics I-II

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VLSI 3: Full-Custom Digital Circuit Design

W 6 credits 2V+3U C. Studer, O. Cañada Fernández

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

At the end of this course, you will

- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption, low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

Literature
N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Prerequisites / notice
- VLSI 3 can be taken in parallel with "VLSI 1: HDL-based design for FPGAs" and is designed to complement the topics of this course. Basic analog circuit knowledge is required.
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Problem-solving

227-0301-00L Optical Communication Fundamentals

| Objective |
| An introduction to the fundamentals of optical communication systems. |

Content
- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes
- Lecture notes are handed out.

Literature
- Govind P. Agrawal; *Fiber-Optic Communication Systems*; Wiley, 2010
- Lecture notes will be made available on the website.

227-0521-00L Emerging Memory Technologies

| Objective |
| Students will learn about the main contenders for post-silicon storage-class memory. Decades of research have made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict that they will replace at least niche hardware applications for ever-growing silicon market. However, some of these technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now. |

Content
- Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other. Selecting to study one technology in more details, students will evaluate its potential and acquire important presenting and critical thinking skills.

227-0116-00L VLSI 1: HDL Based Design for FPGAs

| Objective |
| Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools. |

Content
- This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.
- Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 3 presentations (20-25 min each), followed by the example given by the lecturer.

Literature
- Lecture notes will be made available on the website.
- Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 3 presentations (20-25 min each), followed by the example given by the lecturer.

Lecture notes
- Textbook and all further documents in English.
## Abstract

This course provides the basics of relational databases from the perspective of the user. We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

## Objective

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world’s constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn’t age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

## Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

## Literature

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

## Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

## Examination

In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/
Abstract

The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

Objective

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these (“multiferroics”).

In this course students will obtain an overarching view on oxide epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Content

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

Lecture notes

Lecture notes will be distributed in English

Literature

- Enri: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

327-0703-00L Electron Microscopy in Material Science

W 4 credits 2V+2U S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Kruemeich, K. Kunze

Abstract

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content

This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Lecture notes

Lecture notes will be distributed in English

Literature

- Enri: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

327-0702-00L EM-Practical Course in Materials Science

W 2 credits 4P K. Kunze, S. Gerstl, F. Gramm, F. Kruemeich, J. Reuteler

Abstract

Practical work on TEM, SEM, FIB and APT treatment of typical problems data analysis, writing of a report

Objective

Application of basic electron microscopic techniques to materials science problems

Prerequisites / Literature

see lecture Electron Microscopy (327-0703-00L)

Content

Maximum number of participants 15, work in groups of 3 people.

327-2125-00L Microscopy Training SEM I - Introduction to SEM


Abstract

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTPO.html).

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Objective

- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam-specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes

Lecture notes will be distributed.
Resource and Environmental Economics

363-0537-00L Resource and Environmental Economics W 3 credits 2G L. Bretschger

Abstract
Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

Objective
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental measures to deal with these problems, including the principles of cost-benefit analysis, marginal abatement cost curves, and marginal damage curves. We also cover the economics of pollution control, including the role of market-based instruments like taxes, permits, and tradable pollution permits. The course also covers the economics of renewable resources, including the role of market power, property rights, and technology. A fifth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.
The course aims at enabling students to understand and design experiments that are based on hyperfine coupling between electron and nuclear spins. The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. This semester, the lecture will introduce and discuss the dynamics of electron-nuclear spin systems and experiments based on hyperfine interactions in electron paramagnetic resonance (EPR) spectroscopy and dynamic nuclear polarization (DNP) for sensitivity enhancement in NMR.

The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic concepts are motivated by discussions of technology development. Specific technologies to be covered include, but are not limited to, frequency circuits for multinuclear spin control and detection. An overview of salient interactions in the NMR solid state NMR Hamiltonian, DNP mechanisms, and electron decoupling with nuclear polarization (DNP), with a focus on instrumentation required to perform DNP with magic angle spinning (MAS) NMR. Based on these foundations, we discuss polarization transfer from the electron to the nuclear spin and back, as well as spin diffusion as a mechanism for polarizing nuclear spins beyond the immediate vicinity of the electron spin. The second half of the course will cover dynamic nuclear polarization (DNP), with a focus on instrumentation required to perform pulsed DNP with magic angle spinning (MAS) at ultra-high magnetic fields. A review of salient interactions in the NMR solid state NMR Hamiltonian, DNP mechanisms, and electron decoupling with MAS will motivate discussions of technology development. Specific technologies to be covered include, but are not limited to, frequency circuits for multinuclear spin control and detection. An overview of salient interactions in the NMR solid state NMR Hamiltonian, DNP mechanisms, and electron decoupling with nuclear polarization (DNP), with a focus on instrumentation required to perform DNP with magic angle spinning (MAS) at ultra-high magnetic fields. A review of salient interactions in the NMR solid state NMR Hamiltonian, DNP mechanisms, and electron decoupling with nuclear polarization (DNP), with a focus on instrumentation required to perform DNP with magic angle spinning (MAS) at ultra-high magnetic fields.

The course is structured along three main tasks:

1. Finding solutions
2. Implementing solutions
3. Controlling solutions

PART 1 introduces complexity as a system-immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These then are used to provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as homework and two of these will be graded (see "Prerequisites").

Lecture notes

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

529-0443-01L Advanced Magnetic Resonance

Objective

A successful participant of the course is able to:

- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- set up and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyze the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

Content

Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.

The course is structured along three main tasks:

1. Finding solutions
2. Implementing solutions
3. Controlling solutions

Prerequisites:

A basic knowledge of Magnetic Resonance, e.g., as covered in the Lecture Physical Chemistry IV, or the book “Spin Dynamics” by Malcolm Levitt.

Lecture notes

A script which covers the topics will be distributed in the lecture and will be accessible through the course Moodle.

529-0027-00L Advanced Magnetic Resonance - Solid State NMR

Objective

The aim of the course is to familiarize the students with the basic concepts of modern high-resolution solid-state NMR. Starting from the mathematical description of spin dynamics, important building blocks for multi-dimensional experiments are discussed to allow students a better understanding of modern solid-state NMR experiments. Particular emphasis is given to achieving high spectral resolution.

Content

The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

Lecture notes

A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.ssnmr.ethz.ch/education/

Prerequisites:

A basic knowledge of NMR, e.g., as covered in the Lecture Physical Chemistry IV, or the book by Malcolm Levitt.

529-0433-01L Advanced Physical Chemistry: Statistical Thermodynamics

Objective

Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.
Lecturers: M. Egger, J. Rajczak, S. C. Scherrer

Title: Analysis of Climate and Weather Data

Objective: Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.

Content: Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis. The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

Lecture notes: All material is made available via the lecture web-page.

Literature: For complementary reading:

Prerequisites / notice: Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltwissenschaftern (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

701-1257-00L European Climate Change

Abstract: The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:
- observational datasets, observation and detection of climate change;
- underlying physical processes and feedbacks;
- numerical and statistical approaches;
- currently available projections.

Objective: At the end of this course, participants should:
- understand the key physical processes shaping climate change in Europe;
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
- be familiar with relevant observational and modeling data sets;
- be able to tackle simple climate change questions using available data sets.

Content: Contents:
- global context
- observational data sets, analysis of climate trends and climate variability in Europe
- global and regional climate modeling
- statistical downscaling
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
- projections of European and Alpine climate change

Prerequisites / notice: Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

Data: 18.08.2022 12:39   Autumn Semester 2022   Page 1859 of 2345
Abstract
A guided self-study of original papers and of advanced textbooks in theoretical physics. Within the general topic, determined each
semester, participants give a presentation on a particular subject and deliver a written report.

402-0217-MSL
Semester Project in Theoretical Physics

W
8 credits
15A
Supervisors

Abstract
This course unit is an alternative if no suitable "Proseminar Theoretical Physics" is available of if the proseminar is already overbooked.

Prerequisites / notice
Die Leistungskontrolle erfolgt aufgrund eines oder mehrerer schriftlicher Berichte bzw. einer schriftlichen Arbeit. Vorträge können ein
zusätzlicher Bestandteil der Leistungskontrolle sein.

402-0215-MSL
Experimental Semester Project in Physics

W
8 credits
15A
Supervisors

Abstract
The aim of the project is to give the student experience in working in a research environment, performing physics experiments, analysing
and interpreting the resulting data.

Prerequisites / notice
Die Leistungskontrolle erfolgt aufgrund eines oder mehrerer schriftlicher Berichte bzw. einer schriftlichen Arbeit. Ein Vortrag über die
gewonnenen Ergebnisse ist ein obligatorischer Bestandteil der Leistungskontrolle.

402-0740-00L
Experimental Foundations of Particle Physics

W
8 credits
3S
M. Backhaus, M. Donegà

Abstract
The Standard Model of particle physics is a monumental achievement of human ingenuity. While typically approached from the theoretical
side, in this proseminar we will collect the experimental evidence upon which the Standard Model has been built.

Objective
This course integrates knowledge of all detector components (tracking, calorimetry, trigger) in discussing the experiments as a whole.
It is meant to be complementary to the "Experimental Methods" course 402-0725-00L which introduces different detector technologies.
It also augments the particle physics master curriculum and is meant to be followed in parallel to PPP I (402-0891-00L) or PPP II (402-
0702-00L).

Content
The course will not follow the historical trajectory of experimental particle physics. It will instead try to give a modern view of the results of
the experiments and show where they fit in the theoretical construction.

The students will read the original papers collected in the seminal text by Cahn and Goldhaber. The theory will be distilled to the very
basics using the textbook by Bettini.

- Deep Inelastic scattering
- J/psi and tau discovery
- strong interaction: gluons and jets (anti-k_t jet clustering)
- parity violation, neutrino observation, neutrino helicity
- neutral current, W/Z discovery
- number of neutrino families, muon pair production asymmetry, W+W- production
- top/bottom discoveries
- Higgs discovery and properties
- CP violation in the kaon system
- Neutrino oscillations

The course is completed with in class detector demonstrations:
- cloud chamber
- cosmics rays with plastic scintillators
- cerenkov light in water
- silicon detectors

Literature
Cahn, Goldhaber "Experimental Foundations of Particle Physics" (2nd edition), Cambridge University Press
Bettini, "Introduction to Elementary Particle Physics" Cambridge University Press

Prerequisites / notice
Recommended: Phenomenology of Particle Physics I (or II) (in parallel)

Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
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<td>Social Competencies</td>
<td>Analytical Competencies</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-direction and Self-management</td>
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402-0717-MSL
Particle Physics at CERN

W
8 credits
15P
W. Lustermann

Abstract
During the semester break participating students stay for 4 weeks at CERN and perform experimental work relevant to our particle physics
projects. Dates to be agreed upon.

Objective
Students learn, by doing, the needed skills to perform a small particle physics experiment: setup, problem solving, data taking, analysis,
interpretation and presentation in a written report of publication quality.

Content
Detailed information in: https://ethteilchenpraktikumn.web.cern.ch/

Prerequisites / notice
Language of instruction: English or German

402-0719-MSL
Particle Physics at PSI (Paul Scherrer Institute)

W
8 credits
15P
A. Soter, A. S. Antognini

Abstract
During semester breaks 6-12 students stay for 3 weeks at PSI and participate in a hands-on course on experimental particle physics. A
small real experiment is performed in common, including apparatus design, construction, running and data analysis. The course includes
some lectures, but the focus lies on the practical aspects of experimenting.

Objective
Students learn all the different steps it takes to perform a complete particle physics experiment in a small team. They acquire skills to do
this themselves in the team, including design, construction, data taking and data analysis.

402-0340-MSL
Medical Physics

W
8 credits
15P
A. J. Lomax, K. P. Prüssmann

Abstract
In agreement with the lecturers a semester paper in the context of the topics discussed in the lectures can be written.

Science in Perspective

see Science in Perspective: Type A: Enhancement of
Reflection Capability

Recommended Science in Perspective (Type B) for D-
PHYS

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1860 of 2345
### Master’s Thesis

<table>
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<td><strong>Abstract</strong></td>
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<td>Literature Review: ETH-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX, Mathematical Writing, AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.</td>
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<td>Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.</td>
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<td>Supervisors</td>
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|              | **Only students who fulfill the following criteria are allowed to begin with their master’s thesis:**  
|              | a. successful completion of the bachelor programme;  
|              | b. fulfilling of any additional requirements necessary to gain admission to the master programme.  
|              | c. have acquired at least 8 credits in the category Proseminars and Semester Papers.  
|              | **Further information:** http://www.phys.ethz.ch/phys/education/master/msc-theses |      |       |      |                            |
|              | **Abstract**                                     |      |       |      |                            |
|              | The master’s thesis concludes the study programme. Thesis work should prove the students’ ability to independent, structured and scientific working. |      |       |      |                            |

### Seminars, Colloquia, and Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Research colloquium</td>
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<tr>
<td>402-0800-00L</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>J. Renes, University lecturers</td>
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<td><strong>Abstract</strong></td>
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<td>Research colloquium</td>
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<td>The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.</td>
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<tr>
<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>A. Cattaneo, G. Felder, M. Gaberdiel, G. M. Graf, P. Hintz, T. H. Willwacher</td>
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<td><strong>Abstract</strong></td>
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<tr>
<td>402-0600-00L</td>
<td>Nuclear and Particle Physics with Applications</td>
<td>E-</td>
<td>0 credits</td>
<td>2S</td>
<td>A. Rubbia, K. S. Kirch</td>
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<td><strong>Abstract</strong></td>
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<td>Research colloquium</td>
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<tr>
<td>402-0893-00L</td>
<td>Particle Physics Seminar</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>T. K. Gehrmann</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Occasionally, talks may be delivered in German.</td>
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<tr>
<td>402-0700-00L</td>
<td>Seminar in Elementary Particle Physics</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>M. Spira, University lecturers</td>
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<td><strong>Special Students UZH must book the modul PHY463 directly at UZH.</strong></td>
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<td><strong>Abstract</strong></td>
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<td>Research colloquium</td>
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<td>Stay informed about current research results in elementary particle physics.</td>
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<tr>
<td>402-0746-00L</td>
<td>Seminar: Particle and Astrophysics (Aktuelles aus der Teilchen- und Astrophysik)</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>University lecturers</td>
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<td>In Seminarvorträgen werden aktuelle Fragestellungen aus der Teilchenphysik vom theoretischen und experimentellen Standpunkt aus diskutiert. Besonders wichtig erscheint uns der Bezug zu den eigenen Forschungsmöglichkeiten am PSI, CERN und DESY.</td>
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<tr>
<td>402-0300-00L</td>
<td>IPA Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>A. Biland, A. de Cosa, A. Refregier, H. M. Schmid, further lecturers</td>
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<td><strong>Abstract</strong></td>
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<td>Research colloquium</td>
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<tr>
<td>402-0396-00L</td>
<td>Recent Research Highlights in Astrophysics</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>University lecturers</td>
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<td>(University of Zurich)</td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Recent Research Highlights in Astrophysics (University of Zurich) No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: AST006</td>
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</table>
Mind the enrolment deadlines at UZH:

402-0530-00L  Mesoscopic Systems  E-  0 credits  1S  T. M. Ihn
Abstract  Research colloquium

402-0620-00L  Current Topics in Accelerator Mass Spectrometry and Its Applications  E-  0 credits  2S  M. Christl, S. Willett
Abstract  The seminar is aimed at all students who, during their studies, are confronted with age determination methods based on long-living radionuclides found in nature. Basic methodology, the latest developments, and special examples from a wide range of applications will be discussed.
Objective  The seminar provides the participants an overview about newest trends and developments of accelerator mass spectrometry (AMS) and related applications. In their talks and subsequent discussions the participants learn intensively about the newest trends in the field of AMS thus attaining a broad knowledge on both, the physical principles and the applications of AMS, which goes far beyond the horizon of their own studies.

227-0980-00L  Seminar on Biomedical Magnetic Resonance  E-  0 credits  1S  K. P. Prüssmann, S. Kozerke, M. Weiger Senften
Abstract  Current developments and problems of magnetic resonance imaging (MRI)
Objective  Getting insight into advanced topics in magnetic resonance imaging

227-1043-00L  Neuroinformatics - Colloquia (University of Zurich)  E-  0 credits  1K  S.-C. Liu, R. Hahnloser, V. Mante
Abstract  No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: INI701
Objective  The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.
Objective  The goal of these talks is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.
Content  The topics depend heavily on the invited speakers, and thus change from week to week.

651-1581-00L  Seminar in Glaciology  E-  3 credits  2S  A. Bauder, M. Jacquemart
Abstract  Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.
Objective  In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.
Content  Selected topics of scientific research in Glaciology
Lecture notes  Copies/pdf of scientific papers will be distributed during the course (moodle interface)
Prerequisites / notice  Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L  Kryosphäre
- 101-0289-00L  Applied Glaciology
- 651-4101-00L  Physics of Glaciers

Taught competencies  Subject-specific Competencies
  - Concepts and Theories  assessed
  - Techniques and Technologies  assessed
  - Analytical Competencies  assessed
  - Decision-making  assessed
  - Media and Digital Technologies  assessed
  - Problem-solving  not assessed
  - Project Management  not assessed

  Social Competencies
  - Communication  assessed
  - Cooperation and Teamwork  assessed
  - Customer Orientation  not assessed
  - Leadership and Responsibility  not assessed
  - Self-presentation and Social Influence  assessed
  - Sensitivity to Diversity  assessed
  - Negotiation  assessed

  Personal Competencies
  - Adaptability and Flexibility  assessed
  - Creative Thinking  assessed
  - Critical Thinking  assessed
  - Integrity and Work Ethics  assessed
  - Self-awareness and Self-reflection  assessed
  - Self-direction and Self-management  not assessed

402-0010-00L  Basics of Computing Environments for Scientists  Z  0 credits  1V  C. D. Herzog, C. Becker, S. Müller
Abstract  Enrollment is only possible under https://www.lehrbetrieb.ethz.ch/laborpraktika
No registration required via myStudies.

Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1862 of 2345
Objective
The "IT at D-PHYS" introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.

The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges.

The "Linux Basics" modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization.

The "Python Ecosystem" modules present various aspects on the ecosystem around Python, without covering the programming language itself. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing code. From development environments (IDE, Jupyter), over code formatters and linters, to skimming selected concepts (string formatting, regular expressions).

The "System Aspects module" deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it.

Use the dedicated web page https://www.lehrbetrieb.ethz.ch/laborpraktika to register. Enrolled students are eligible for an attendance of at least 3 out of the 5 modules. Refer to https://compenv.phys.ethz.ch for the detailed contents.

Content
Introduction:
IT at D-PHYS (IT service providers and IT services at D-PHYS)

Modules:
- Linux Basics I (system components, basic shell usage)
- Linux Basics II (advanced tools, scripting)
- Python Ecosystem I (interpreters, packages, virtual environments)
- Python Ecosystem II (development environments, formatter and linter, string formatting, regexp)
- System Aspects (how the structure affects your scientific code and vice versa)

Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>406-0204-AAL</td>
<td>Electrodynamics</td>
<td>E-</td>
<td>7</td>
<td>15R</td>
<td>J. Brödel</td>
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<tr>
<td>401-2673-AAL</td>
<td>Numerical Methods for CSE</td>
<td>E-</td>
<td>9</td>
<td>19R</td>
<td>R. Hiptmair</td>
</tr>
</tbody>
</table>

Abstract
- Derivation and discussion of Maxwell's equations, from the static limit to the full dynamical case. Wave equation, waveguides, cavities.

Objectives
- Develop a physical understanding for static and dynamic phenomena related to (moving) charged objects and understand the structure of the classical field theory of electrodynamics (transverse versus longitudinal physics, invariances (Lorentz-, gauge-)). Appreciate the interrelation between electric, magnetic, and optical phenomena and the influence of media. Understand a set of classic electrodynamical phenomena and develop the ability to solve simple problems independently. Apply previously learned mathematical concepts (vector analysis, complete systems of functions, Green's functions, co- and contravariant coordinates, etc.). Prepare for quantum mechanics (eigenvalue problems, wave guides and cavities).

Content
- Classical field theory of electrodynamics: Derivation and discussion of Maxwell equations, starting from the static limit (electrostatics, magnetostatics, boundary value problems) in the vacuum and in media and subsequent generalization to the full dynamical case (Faraday's law, Amperes/Maxwell law; potentials and gauge invariance). Wave equation and solutions in full space, half-space (Snell's law), waveguides, cavities, generation of electromagnetic radiation, scattering and diffraction of light (optics). Application to various specific examples. Discussion of the structure of Maxwell's equations, Lorentz invariance, relativity theory and covariance, Lagrangian formulation. Dynamics of relativistic particles in the presence of fields and radiation properties (synchrotron).

Literature
- J.D. Jackson, Classical Electrodynamics
- W.K.H Panovsky and M. Phillips, Classical electricity and magnetism
- A. Sommerfeld, Elektrodynamik, Optik (Vorlesungen über theoretische Physik)
- M. Born and E. Wolf, Principles of optics
- R. Feynman, R. Leighton, and M. Sands, The Feynman Lectures of Physics, Vol II
Lecture notes

Lecture materials (PDF documents and codes) will be made available to participants.


M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice

Solid knowledge about fundamental concepts and techniques from linear algebra & calculus as taught in the first year of science and engineering curricula.

The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves.

Physics Master - Key for Type

| Z | Courses outside the curriculum | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Dr | Suitable for doctorate |
| W | Eligible for credits | O | Compulsory |

Key for Hours

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |
| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Data: 18.08.2022 12:39   Autumn Semester 2022   Page 1864 of 2345
Quantitative Finance Master

see www.msfinance.ch/index.html?portrait/Curriculum.html

Students in the Joint Degree Master's Programme "Quantitative Finance" must book University of Zurich modules directly at the University of Zurich. Those modules are not listed here.

Core

FIN (Finance)

For possible (additional) course offerings see www.msfinance.ch

MF (Mathematical Methods in Finance)

For possible additional course offerings see www.msfinance.ch

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4</td>
<td>3V+2U</td>
<td>M. Schweizer</td>
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<tr>
<td>Abstract</td>
<td>First introduction to modelling ideas and mathematical tools from mathematical finance</td>
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<tr>
<td>Objective</td>
<td>This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.</td>
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<td>Content</td>
<td>Topics to be covered include</td>
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<td>- financial market models in finite discrete time</td>
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<td>- absence of arbitrage and martingale measures</td>
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<td>- valuation and hedging in complete markets</td>
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<td>- basics about Brownian motion</td>
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<td>- stochastic integration</td>
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<td>- stochastic calculus: Ito's formula, Girsanov transformation, Ito's representation theorem</td>
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<td>- Black-Scholes formula</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes will be sold at the beginning of the course.</td>
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<tr>
<td>Literature</td>
<td>Lecture notes will be sold at the beginning of the course. Additional (background) references are given there.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Results and facts from probability theory as in the book &quot;Probability Essentials&quot; by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course &quot;Wahrscheinlichkeitsrechnung &quot;.) For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.</td>
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Elective

FIN (Finance)

For possible additional course offerings see www.msfinance.ch

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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-4633-00L</td>
<td>Data Analytics in Organisations and Business</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>I. Flückiger</td>
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<tr>
<td>Abstract</td>
<td>This lecture covers organizations and businesses’ end-to-end data analytics process and deepens each process stage. It shows why a stage is needed and what actions are taken in each stage. It gives steps successfully applied in practice and loopholes when issues arise. Case studies from various industries will be presented for each stage.</td>
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<td>Objective</td>
<td>This course aims to give the students an understanding of the whole data analytics life cycle in the business world. It shows the expectations of companies and how it is measured. It enables the student to manage successfully all the non-methodological aspects of a data analytics project which are the primary source of failure in end-to-end executions. The student will become familiar with the &quot;business language, and cultural aspects of organizations. It also gives an overview of the data analytics tool, platform, and methods ecosystem for successfully technical data analyses.</td>
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<tr>
<td>Content</td>
<td>1) Introduction</td>
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<td>2) Framing the business problem</td>
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<td>3) Framing the analytics problem</td>
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<td>4) Data</td>
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<td>5) Identification of problem-solving approaches and appropriate tools</td>
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<td>6) How to set up and validate models</td>
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<td>7) The deployment of a model</td>
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<td>8) Model lifecycle</td>
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<td>9) Operating models and roles</td>
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<td>10) Some words about soft skills needed by statistical and mathematical professionals</td>
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<tr>
<td>Lecture notes</td>
<td>The lecture's presentation slides will be provided.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic statistics and probability theory and regression</td>
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363-1081-00L Asset Liability Management and Treasury Risks

Number of participants limited to 40.

Abstract

Asset Liability Management (ALM) is key to the financial success of any corporation. The goal is to develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and related profits and losses, including identification and mitigation of undue risks taken. This course is geared towards preparing students to apply these concepts in practical settings.

Objective

The main learning objectives of this course are:
- develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and their respective contributions to profits and losses
- measure and assess exposures to risk factors such as interest and FX rates, equity and commodity prices, as well as liquidity events
- trading and hedging to mitigate undue risks incurred
Content

The course is organized around a series of case studies. We will first discuss and develop an understanding of the fundamentals on different aspects of the management and risk management of the balance sheet. Using real life case studies each concept will then be directly applied and tested. In-class discussions, presentations and one written assignment are used to facilitate active and interactive learning in a stimulating environment. During the case studies students will frequently work in small groups. Therefore, the number of participants is limited to 40.

The course focuses on the application of finance concepts to the financial management of corporations and is geared towards preparing students to apply these concepts in practical settings. Executives of all sectors are expected to have a sound understanding of the content covered. As such, the course is not exclusively targeted at students who are exclusively targeting a career in the financial services sector. It also recommended for students who want to work in the finance, treasury or risk area of corporates. It is also suitable for students who want to work for a consultancy firm.

Literature

No single textbook covers the course, below we list some useful references. Further materials will be made available to students prior to the lectures


Prerequisites / notice

Participants should have a basic understanding of financial management, gained, for example, from prior undergraduate economics, business, or accounting studies.

 воздымах приступать к статистике, а не к учету. Математические методы в финансах следует применять для статистики, а не для учета.

 iterators of the different parts from different books as well as on original research literature.

 MF (Mathematical Methods in Finance)

For possible additional course offerings see www.mfinance.ch

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3925-00L</td>
<td>Non-Life Insurance: Mathematics and Statistics</td>
<td>W</td>
<td>8</td>
<td>4V+1U</td>
<td>M. V. Wüthrich</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.</td>
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<tr>
<td>Objective</td>
<td>The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.</td>
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<tr>
<td>Content</td>
<td>The following topics are treated:</td>
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<td></td>
<td>Collective Risk Modeling</td>
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<td>Individual Claim Size Modeling</td>
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<td>Approximations for Compound Distributions</td>
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<td>Ruin Theory in Discrete Time</td>
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<td>Premium Calculation Principles</td>
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<td>Generalized Linear Models and Neural Networks</td>
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<td>Bayesian Models and Credibility Theory</td>
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<td>Claims Reserving</td>
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<td></td>
<td>Solvency Considerations</td>
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<tr>
<td>Lecture notes</td>
<td>M.V. Wüthrich, Non-Life Insurance: Mathematics &amp; Statistics</td>
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</tr>
<tr>
<td>Literature</td>
<td>M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The exams ONLY take place during the official ETH examination period (and they will be in person at ETH, this also applies to exchange/mobility students).</td>
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This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Tuited competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

Methods and Technologies

- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Lecture notes

The course is based on different parts from different books as well as on original research literature.

Lecture notes will not be available.
Prerequisites / notice

Prerequisites are the standard courses
- Probability Theory (for which lecture notes are available)
- Brownian Motion and Stochastic Calculus (for which lecture notes are available)

Those students who already attended "Introduction to Mathematical Finance" will have an advantage in terms of ideas and concepts.

This course is the second of a sequence of two courses on mathematical finance. The first course "Introduction to Mathematical Finance" (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imst/education/education-in-stochastic-finance/overview-of-courses.html.

401-4657-00L Numerical Solution of Stochastic Ordinary Differential Equations  W  6 credits  3V+1U  A. Stein

Abstract

This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective

The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content

Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes

There will be English, typed lecture notes for registered participants in the course.

Literature


Prerequisites / notice

Prerequisites:
Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.

a) mandatory courses:
Elementary Probability, Probability Theory I.

b) recommended courses:
Stochastic Processes.

Start of lectures: Wednesday September 21, 2022.

401-3929-00L Financial Risk Management in Social and Pension Insurance  W  4 credits  2V  P. Blum

Abstract

Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. We study short-term and long-term financial risk and its interplay with other risk factors, and we develop methods for the measurement and management of financial risk and return in an asset/liability context with the goal of assuring sustainable funding.
Objective

Understand the basic asset-liability framework: essential principles and properties of social and pension insurance; cash flow matching, duration matching, valuation portfolio and loose coupling; the notion of financial risk; long-term vs. short-term risk; coherent measures of risk.

Understand the conditions for sustainable funding: derivation of required returns; interplay between return levels, contribution levels and other parameters; influence of guaranteed benefits.

Understand the notion of risk-taking capability: capital process as a random walk; measures of long-term risk and relation to capital; short-term solvency vs. long-term stability; effect of embedded options and guarantees; interplay between required return and risk-taking capability.

Be able to study empirical properties of financial assets: the Normal hypothesis and the deviations from it; statistical tools for investigating relevant risk and return properties of financial assets; time aggregation properties; be able to conduct analysis of real data for the most important asset classes.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Content

Have an overall view: see the big picture of what asset returns can and cannot contribute to social security; be aware of the most relevant outcomes; know the role of the actuary in the financial risk management process.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of
1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.

401-3922-00L Life Insurance Mathematics W 4 credits 2V M. Koller

Abstract

The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

401-3928-00L Reinsurance Analytics W 4 credits 2V

Abstract

Does not take place this semester.

Objective

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities

Objective

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

Lecture notes:
Slides and lecture notes will be made available.

Prerequisites / notice:
Basic knowledge in statistics, probability theory, and actuarial techniques.

Taught competencies:
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<tr>
<th>Subject-specific Competencies</th>
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</table>

401-3931-00L Responsible Machine Learning with Insurance Applications

W 4 credits 2G M. Mayer, C. Lorentzen-Geiser

Abstract:
The lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

Objective:
The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

Content:
- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

Prerequisites / notice:
This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Prerequisites: Good knowledge in statistics/probability theory, statistical modelling and the R programming language are assumed.

Master’s Thesis

see www.oec.uzh.ch/studies/general/theses/oec_en.html

Quantitative Finance Master - Key for Type

| O   | Compulsory |
| W+  | Eligible for credits and recommended |
| W   | Eligible for credits |

| E-  | Recommended, not eligible for credits |
| Z   | Courses outside the curriculum |
| Dr  | Suitable for doctorate |

Key for Hours

| V   | lecture |
| G   | lecture with exercise |
| U   | exercise |
| S   | seminar |
| K   | colloquium |

| P   | practical/laboratory course |
| A   | independent project |
| D   | diploma thesis |
| R   | revision course / private study |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Quantum Engineering Master

- **Core Courses**
  
  A minimum of 24 credits must be obtained from core courses during the MSc QE, course selection is subject to the tutor's agreement.

- **Quantum Technology Lab**
  
  This core course is a prerequisite for participation in the QuanTech Labs of the second and third semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1831-10L</td>
<td>Case Studies: Applications of Quantum Technology</td>
<td>W+</td>
<td>3 credits</td>
<td>6G</td>
<td>G. Raino</td>
</tr>
</tbody>
</table>

- **Engineering Core Courses**

  These core courses target students with a physics background and all those who need additional engineering foundations.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
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</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1870 of 2345
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system.

This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements. The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Content

Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors. The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes

Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature


227-0301-00L Optical Communication Fundamentals W 6 credits 2V+1U+1P J. Leuthold

Abstract

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system.

Content

* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
* Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes

Lecture notes are handed out.

Literature

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

Prerequisites / notice


227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Content

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Physics Core Courses

These core courses target students with an engineering background and all those who need additional physics foundations.

Number Title Type ECTS Hours Lecturers

402-0205-00L Quantum Mechanics I W 10 credits 3V+2U C. Anastasiou

Abstract


Objective

Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

Content

The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.

Lecture notes

Auf Moodle

Literature

G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics
This is an introduction to the physics of quantum mechanics, aimed primarily at students with little to no background in physics. We start from the basic postulates and follow an information-theoretical approach to study the behaviour of quantum systems, from a single spin to entangled particles in space and the hydrogen atom.

Prerequisites / notice
This course is aimed at non-physicists, and in particular at students with a background in computer science, mathematics or engineering. Basic linear algebra and calculus knowledge is required (equivalent to first-year courses). Physics knowledge is not required. Physicists and students from a different background than outlined above are welcome at their own risk.

Note that while we follow an information-theoretical approach, this is not a course on quantum information theory or quantum computing. It therefore complements those courses offered at ETH in both semesters.

402-0209-00L Quantum Physics for Non-Physicists

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Abstract
This course teaches the basics of quantum physics, and complements courses in quantum computation and information theory. Students are equipped with tools to tackle complex quantum mechanical problems and foundational questions. The course covers approximately the same content as QM1, but from an information-driven perspective.

Content
Quantum formalism, from qubits to particles in space; Time and dynamics for quantum systems; Problems in 1D; Uncertainty and open systems; Spin; Problems in 3D; Non-locality and foundational aspects of quantum theory

Lecture notes
Lecture notes will be distributed through the semester.

402-0255-00L Introduction to Solid State Physics

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
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<tr>
<td></td>
<td></td>
<td>Media and Digital Technologies</td>
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<tr>
<td></td>
<td>Social Competencies</td>
<td>Communication</td>
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<tr>
<td></td>
<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<td></td>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td></td>
<td>Self-presentation and Social Influence</td>
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<td></td>
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<td>Sensitivity to Diversity</td>
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<td></td>
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<td>Negotiation</td>
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<tr>
<td></td>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td></td>
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<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

Abstract
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.

Objective
Introduction to Solid State Physics.
402-0442-00L Quantum Optics W 10 credits 3V+2U A. Imamoglu

Abstract This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

Objective The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand and currently published research in the field.

Content This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:

- coherence properties of light
- quantum nature of light; statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

Lecture notes Selected book chapters will be distributed.

Literature Text-books:

G. Grymberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
R. Loudon, The Quantum Theory of Light
Atomic Physics, Christopher J. Foot
Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
C. Cohen-Tannoudji et al., Atom-Photon-Interactions
M. Scully and M.S. Zubairy, Quantum Optics
Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

402-0861-00L Statistical Physics W 10 credits 4V+2U E. Demler

Abstract This course covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.

Objective This lecture gives an introduction to the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.

Content Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.

Classical statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.

Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons.

Identical quantum particles: many body wave functions, second quantization formalism, equations of motion, correlation functions, selected applications, e.g. Bose-Einstein condensate and coherent state, phonons in elastic media and melting.

One-dimensional interacting systems.

Phase transitions: mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls' arguments on long-range order.


Lecture notes Lecture notes available in English.

Literature No specific book is used for the course. Relevant literature will be given in the course.

402-0461-00L Quantum Information Theory W 8 credits 3V+1U J. Renes

Abstract The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.

Objective By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.

Content Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

Lecture notes Distributed via moodle.

Literature Nielsen and Chuang, Quantum Information and Computation
Preskill, Lecture Notes on Quantum Computation
Wilde, Quantum Information Theory
Watrous, The Theory of Quantum Information

▶ Electives

This is a selection of courses particularly suitable for the MSc QE. In agreement with the tutor, students may choose other courses from the ETH course catalogue.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

Abstract The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective The course introduces some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.
1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0145-00L</td>
<td>Solid State Electronics and Optics</td>
<td>W 6</td>
<td>N. Yazdani, V. Wood</td>
</tr>
<tr>
<td>Abstract</td>
<td>&quot;Solid State Electronics&quot; is an introductory condensed matter physics course covering crystal structure, electron models, classification of metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and optical properties of solids.</td>
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<tr>
<td>Content</td>
<td>Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.</td>
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<tr>
<td>Literature</td>
<td>Slides are available online under <a href="https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/">https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/</a></td>
<td></td>
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<tr>
<td>Prerequisites / notice</td>
<td>Undergraduate physics, mathematics, semiconductor devices</td>
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</tr>
<tr>
<td>227-0146-00L</td>
<td>Analog-to-Digital Converters</td>
<td>W 6</td>
<td>T. Burger</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.</td>
<td></td>
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<tr>
<td>Content</td>
<td>Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. The student will learn to understand the basic principles behind data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained with their principle of operation accompanied with the appropriate mathematical calculations, including the effects of non-idealities in some cases. After successful completion of the course the student should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Slides are available online under <a href="https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/">https://iis-students.ee.ethz.ch/lectures/analog-to-digital-converters/</a></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>It is highly recommended to attend the course &quot;Analog Integrated Circuits&quot; of Prof. T. Jang as a preparation for this course.</td>
<td></td>
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</tr>
<tr>
<td>227-0157-00L</td>
<td>Semiconductor Devices: Physical Bases and Simulation</td>
<td>W 4</td>
<td>C. I. Roman</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.</td>
<td></td>
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<tr>
<td>Content</td>
<td>The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>The script (in book style) can be downloaded from: <a href="https://iis-students.ee.ethz.ch/lectures/">https://iis-students.ee.ethz.ch/lectures/</a></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Qualifications: Physics I-II, Semiconductor devices (4. semester).</td>
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</tr>
<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>W 6</td>
<td>T. Jang</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.</td>
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<tr>
<td>Notice</td>
<td>The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.</td>
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</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1874 of 2345
Content
Review of bipolar and MOS devices and their small-signal equivalent circuit models: Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes
Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature

227-0225-00L Linear System Theory

W 6 credits 5G J. Lygeros, A. Tsiamis

Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes
Available on the course Moodle platform.

Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

227-0311-00L Qubits, Electrons, Photons

W 6 credits 3V+2U T. Zambelli

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!) basis which will help them in their advanced studies of the following masters: EIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

Content
- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Prerequisites / notice

Literature
• (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, “Lectures on the Mathematics of Quantum Mechanics I”, 2015, Springer
• (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.

Supplementary material will be uploaded in Moodle.

IMPORTANT: “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

...... I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
The base for these lectures are lecture notes and two or three published scientific papers. From these papers, we will together develop the technical content.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of CM-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.
### Electromagnetic Precision Measurements and Opto-Mechanics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>227-0653-00L</td>
<td>Electromagnetic Precision Measurements and Opto-Mechanics</td>
<td>W 4</td>
<td>2V+1U</td>
<td>M. Frimmer</td>
</tr>
</tbody>
</table>

**Abstract**

The measurement process is at the heart of both science and engineering. Electromagnetic fields have proven to be particularly powerful probes. This course provides the basic knowledge necessary to understand current state-of-the-art optomechanical measurement systems operating at the precision limits set by the laws of quantum mechanics.

**Objective**

The goal of this course is to understand the fundamental limitations of measurement systems relying on electromagnetic fields.

**Content**

- The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection.
- Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics.

**Prerequisites / notice**

1. Electrodynamics
2. Physics 1.2
3. Introduction to quantum mechanics

### Intersubband Optoelectronics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>402-0465-5BL</td>
<td>Intersubband Optoelectronics</td>
<td>W 6</td>
<td>2V+1U</td>
<td>G. Scalari</td>
</tr>
</tbody>
</table>

**Abstract**

Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent taylorribility, this system can be seen as the "ultimate quantum designer's material".

**Objective**

The goal of this lecture is to explore both the rich physics as well as the application of these system for sources and detectors. In fact, devices based on intersubband transitions are now unlocking large area of the electromagnetic spectrum.

**Content**

- The lecture will treat the following chapters:
  - Introduction: intersubband optoelectronics as an example of quantum engineering
  - Technological aspects
  - Electronic states in semiconductor quantum wells
  - Intersubband absorption and scattering processes
  - Mid-IR and THz ISB Detectors
  - Mid-infrared and THz photonics: waveguides, resonators, metamaterials
  - Quantum Cascade lasers:
    - Mid-IR QCLs
    - THZ QCLs (direct and non-linear generation)
  - Further electronic confinement: interlevel Qdot transitions and magnetic field effects
  - Strong light-matter coupling in Mid-IR and THz range

**Lecture notes**

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

**Literature**

- Mostly the original articles, other useful reading can be found in:
  - E. Rosencher and B. Vinter, Optoelectronics, Cambridge Univ. Press
  - G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press

**Prerequisites / notice**

Requirements: A basic knowledge of solid-state physics and of quantum mechanics.

### Nonlinear Optics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0655-00L</td>
<td>Nonlinear Optics</td>
<td>W 6</td>
<td>2V+2U</td>
<td>J. Leuthold</td>
</tr>
</tbody>
</table>

**Abstract**

Nonlinear Optics deals with the interaction of light with material, the response of material to light and the mathematical framework to describe the phenomena. As an example we will cover fundamental phenomena such as the refractive index, the electro-optic effect, second harmonic generation, four-wave mixing or soliton propagation and others.

**Objective**

The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematical by means of the susceptibility.

**Content**

- Chapter 1: The Wave Equations in Nonlinear Optics
- Chapter 2: Nonlinear Effects - An Overview
- Chapter 3: The Nonlinear Optical Susceptibility
- Chapter 4: Second Harmonic Generation
- Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator
- Chapter 6: Acousto-Optic Effect
- Chapter 7: Nonlinear Effects of Third Order
- Chapter 8: Nonlinear Effects in Media with Gain

**Literature**

Lecture notes are distributed. For students enrolled in the course, additional information, lecture notes and exercises can be found on moodle (https://moodle-app2.let.ethz.ch/).

**Prerequisites / notice**

Requirements: A basic knowledge of solid-state physics and of quantum mechanics.

### Nano-Optics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0663-00L</td>
<td>Nano-Optics</td>
<td>W 6</td>
<td>2V+2U</td>
<td>M. Frimmer</td>
</tr>
</tbody>
</table>

**Abstract**

Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

**Objective**

Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

**Content**

- We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

**Literature**

- Requirements: Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics

### Dynamic Programming and Optimal Control

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0565-01L</td>
<td>Dynamic Programming and Optimal Control</td>
<td>W 4</td>
<td>2V+1U</td>
<td>R. D’Andrea</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to Dynamic Programming and Optimal Control. Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Objective**

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems; Bellman Equation; Deterministic Continuous-Time Optimal Control

**Content**


**Literature**

- Dynamic Programming and Optimal Control

**Prerequisites / notice**

Data: 18.08.2022 12:39 | Autumn Semester 2022 | Page 1877 of 2345
**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- **Fundamentals:**
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- **Supervised learning:**
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- **Unsupervised learning:**
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation

- **Learning Dynamical Systems**

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


**Prerequisites / notice**

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**252-0836-00L**

<table>
<thead>
<tr>
<th>Computer Science II</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>M. Schwerhoff, F. O. Friedrich Wicker</th>
</tr>
</thead>
</table>

**Abstract**

The course provides the foundations for the design and analysis of algorithms. Classical problems ranging from sorting up to problems on graphs are used to discuss common data structures, algorithms and algorithm design paradigms. The course also comprises an introduction to parallel and concurrent programming.

**Objective**

An understanding of the analysis and design of fundamental and common algorithms and data structures. Knowledge regarding chances, problems and limits of parallel and concurrent programming.

**Content**

Data structures and algorithms: mathematical tools for the analysis of algorithms (asymptotic function growth, recurrence equations, recurrence trees), informal proofs of algorithm correctness (invariants and code transformation), design paradigms for the development of algorithms (induction, divide-and-conquer, backtracking and dynamic programming), classical algorithmic problems (searching, selection and sorting), data structures for different purposes (linked lists, hash tables, balanced search trees, heaps, union-find), further tools for runtime analysis (generating functions, amortized analysis). The relationship and tight coupling between algorithms and data structures is illustrated with graph algorithms (traversals, topological sort, closure, shortest paths, minimum spanning trees).

Parallel programming: structure of parallel architectures (multicore, vectorization, pipelining) concepts of parallel programming (Amdahls and Gustavson's laws, task/data parallelism, scheduling), problems of concurrency (data races, bad interleavings, memory reordering), process synchronisation and communication in a shared memory system (mutual exclusion, semaphores, monitors, condition variables). The concepts are underpinned with examples of concurrent and parallel programs and with parallel algorithms, implemented in C++.

In general, the concepts provided in the course are motivated and illustrated with practically relevant algorithms and applications.

Exercises are carried out in Code-Expert, an online IDE and exercise management system.

**Lecture notes / Literature**

All required mathematical tools above high school level are covered, including a introduction to graph theory.


**Prerequisites / notice**

Prerequisite: Computer Science I

**402-0257-00L**

<table>
<thead>
<tr>
<th>Advanced Solid State Physics</th>
<th>W</th>
<th>10 credits</th>
<th>3V+2U</th>
<th>A. Zheludev</th>
</tr>
</thead>
</table>

**Abstract**

This course is an extension of the introductory course on solid state physics. The purpose of this course is to learn to navigate the complex collective quantum phases, excitations and phase transitions that are the dominant theme in modern solid state physics. The emphasis is on the main concepts and on specific experimental examples, both classic ones and those from recent research.

**Objective**

The goal is to study how novel phenomena emerge in the solid state.
Content

**Today's challenges and opportunities in Solid State Physics**

- Phase transitions and critical phenomena
  - Main concepts: coherence length, symmetry, order parameter, correlation functions, generalized susceptibility
  - Landau theory of phase transitions
  - Fluctuations in Landau theory
  - Critical exponents: significance, measurement, inequalities, equalities
  - Scaling, hyperscaling and universality
  - Quantum phase transitions and quantum criticality

- Fermi surface instabilities
  - The concept of the Landau Fermi liquid in metals
  - Kohn anomalies
  - Charge density waves
  - Metallic ferromagnets and half-metals
  - Spin density waves
  - Superconductivity

- Magnetism of insulators
  - Magnetic interactions in solids and the spin Hamiltonian
  - Magnetic structures and phase transitions
  - Spin waves
  - Quantum magnetism

- Electron correlations in solids
  - Mott insulating state
  - Phases of the Hubbard model

Lecture notes

The printed material for this course involves: (1) a self-contained script, distributed electronically at semester start. (2) Experimental examples (Power Point slide-style) selected from original publications, distributed at the start of every lecture.

Literature

A list of books will be distributed. Numerous references to useful published scientific papers will be provided.

Prerequisites / notice

This course is for students who like to be engaged in active learning. The "exercise classes" are organized in a non-traditional way: following the idea of "less is more", we will work on only about half a dozen topics, and this gives students a chance to take a look at original literature (provided), and to get the grasp of a topic from a broader perspective.

Students report back that this mode of "exercise class" is more satisfying than traditional modes, even if it does not mean less effort.

---

402-0317-00L  **Semiconductor Materials: Fundamentals and Fabrication**  W  6 credits  2V+1U  S. Schön, W. Wegscheider

**Abstract**

This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

**Objective**

Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

**Content**

1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

**Lecture notes**

https://moodle-app2.let.ethz.ch/course/view.php?id=

**Prerequisites / notice**

The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

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402-0402-00L  **Ultrafast Laser Physics**  W  10 credits  3V+2U  L. P. Gallmann, S. Johnson, U. Keller

**Abstract**

Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.

**Objective**

Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.
The lecture covers the following topics:

a) Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product

b) Dispersion compensation: technologies for controlling dispersion, pulse shaping, measurement of dispersion

c) Nonlinear pulse propagation: intensity-dependent refractive index (Kerr effect), self-phase modulation, nonlinear pulse compression, self-focusing. filamentation, nonlinear Schrödinger equation, solitons, non-instantaneous nonlinear effects (Raman/Brillouin), self-steepening, saturable gain and absorption

d) Second-order nonlinearities with ultrashort pulses: phase-matching with short pulses and real beams, quasi-phase matching, second-harmonic and sum-frequency generation, parametric amplification and generation

e) Relaxation oscillations: dynamical behavior of rate equations after perturbation

f) Q-switching: active Q-switching and its theory based on rate equations, active Q-switching technologies, passive Q-switching and theory

g) Active modelocking: introduction to modelocking, frequency comb versus axial modes, theory for various regimes of laser operation, Haus master equation formalism

h) Passive modelocking: slow, fast and ideally fast saturable absorbers, semiconductor saturable absorber mirror (SESAM), designs of and materials for SESAMs, modelocking with slow absorber and dynamic gain saturation, modelocking with ideally fast saturable absorber, Kerr-lens modelocking, soliton modelocking, Q-switching instabilities in modelocked lasers, inverse saturable absorption

i) Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more

j) Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection

k) Ultrafast measurements: pump-probe scheme, transient absorption/differential transmission spectroscopy, four-wave mixing, optical gating and more

l) Frequency combs and carrier-envelope offset phase: measurement and stabilization of carrier-envelope offset phase (CEP), time and frequency domain applications of CEP-stabilized sources

m) High-harmonic generation and attosecond science: non-perturbative nonlinear optics / strong-field phenomena, high-harmonic generation (HHG), phase-matching in HHG, attosecond pulse generation, attosecond technology: detectors and diagnostics, attosecond metrology (streaking, RABITT, transient absorption, attoclock), example experiments

n) Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications

o) Brief introduction to other hot topics: relativistic and ultra-high intensity ultrafast science, ultrafast electron sources, free-electron lasers, etc.

Prerequisites: Basic knowledge of quantum mechanics (e.g., 402-0275-00L Quantenelektronik).

Masters level quantum optics knowledge

A collection of review articles (will be pointed out during the lecture)

Lecture notes

Class notes will be made available.

Literature

C. Cohen-Tannoudji et al., Atom-Photon-Interactions (recommended)

Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics (recommended)

Lecture notes

Lecture notes will be provided

Prerequisites / notice

Does not take place this semester.

Abstract

This course builds up on the material covered in the Quantum Optics course. The emphasis will be on quantum optics in condensed-matter systems.

Objective

The course aims to provide the knowledge necessary for pursuing advanced research in the field of Quantum Optics in condensed matter systems. Fundamental concepts and techniques of Quantum Optics will be linked to experimental research in systems such as quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

Content


Prerequisites / notice

Masters level quantum optics knowledge

Quantum Science with Superconducting Circuits

Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.

Based on today’s most advanced solid state platform for quantum control, the students will learn how to engineer quantum coherent devices and how to use them to process quantum information. The students will acquire both analytical and numerical methods to model the properties and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.


All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

Quantum Technologies for Searches of New Physics

Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.

Based on today’s most advanced solid state platform for quantum control, the students will learn how to engineer quantum coherent devices and how to use them to process quantum information. The students will acquire both analytical and numerical methods to model the properties and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.


All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.
Abstract
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

Objective
The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

Content
The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.
- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

Prerequisites / notice
The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

402-0464-00L Optical Properties of Semiconductors

Abstract
This course presents a comprehensive discussion of optical processes in semiconductors.

Objective
The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these material, enabled numerous applications (lasers, LEDs and solar cells) as well as the realization of new physical concepts. Systems that will be covered include quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

Content
Electronic states in III-V materials and quantum structures, optical transitions, excitons and polaritons, novel two dimensional semiconductors, spin-orbit interaction and magneto-optics.

Prerequisites / notice
Prerequisites: Quantum Mechanics I, Introduction to Solid State Physics

402-0468-15L Nanomaterials for Photonics

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.
Content

1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes

Slides and book chapter will be available for downloading

Literature

References will be given during the lecture

Prerequisites / notice

Basics of solid-state physics (i.e. energy bands) can help

402-0469-67L Parametric Phenomena

W 6 credits 3G A. Eichler

Abstract

There are numerous physical phenomena that rely on time-dependent Hamiltonians (or parametric driving) to amplify, cool, squeeze or couple resonating systems. In this course, we will introduce parametric phenomena in different fields of physics, ranging from classical engineering ideas to devices proposed for quantum neural networks.

Objective

This course is intended for
- experimentalists who desire to gain a solid theoretical understanding of nonlinear driven-dissipative systems,
- theorists looking to expand their analytical and numerical toolbox,
- any scientist interested to learn what lies beyond the harmonic resonator.

In the course, the students will grasp the ubiquitous nature of parametric phenomena and apply it to both classical and quantum systems. The students will understand both the theoretical foundations leading to the parametric drive as well as the experimental aspect related to the realizations of the effect. Each student will analyze an independent system using the tools acquired in the course and will present his/her insights to the class.

Content

This course will provide a general framework for understanding and linking various phenomena, ranging from the child-on-a-swing problem to quantum limited amplifiers, to optical frequency combs, and to optomechanical sensors used in the LIGO experiment. The course will combine theoretical lectures and the study of important experiments through literature.

The students will receive an extended lecture summary as well as numerous MATHEMATICA and Python scripts, including QuTiP notebooks. These tools will enable them to apply analytical and numerical methods to a wide range of systems beyond the duration of the course.

Lecture notes

A full script will be available.
The students should be familiar with wave mechanics as well as second quantization. Following the course requires a laptop with Python and MATHEMATICA installed.

**402-0484-00L**  
**Experimental and Theoretical Aspects of Quantum Gases**  
**W** 6 credits  **2V+1U**  
T. Esslinger

*Abstract*  
Quantum Gases are the most precisely controlled many-body systems in physics. This provides a unique interface between theory and experiment, which allows addressing fundamental concepts and long-standing questions. This course lays the foundation for the understanding of current research in this vibrant field.

*Objective*  
The lecture conveys a basic understanding for the current research on quantum gases. Emphasis will be put on the connection between theory and experimental observation. It will enable students to read and understand publications in this field.

*Content*  
Cooling and trapping of neutral atoms

- Bose and Fermi gases
- Ultracold collisions
- The Bose-condensed state
- Elementary excitations
- Vortices
- Superfluidity

*Lecture notes*  
notes and material accompanying the lecture will be provided

*Literature*  


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**402-0535-00L**  
**Introduction to Magnetism**  
**W** 6 credits  **3G**  
A. Vindigni

*Abstract*  
Atomic paramagnetism and diamagnetism, itinerant and local-moment interatomic coupling, magnetic order at finite temperature, spin precession, approach to equilibrium through thermal and quantum dynamics, dipolar interaction in solids.

*Objective*  
- Apply concepts of quantum-mechanics to estimate the strength of atomic magnetic moments and their interactions
- Identify the mechanisms from which exchange interaction originates in solids (itinerant and local-moment magnetism)
- Evaluate the consequences of the interplay between competing interactions and thermal energy
- Apply general concepts of statistical physics to determine the origin of bistability in realistic magnets
- Discriminate the dynamic responses of a magnet to different external stimuli

*Content*  
The lecture "Introduction to Magnetism" is a regular course of the Physics MSc program and aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what "being magnetic" means is essential to address this question properly. Theoretical concepts will be applied to few selected nano-sized magnets, which will serve as clean reference systems.

At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

*Preliminary contents for the HS21:*  
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field)
- Spin resonance and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)
- Magnetic order at finite temperatures (Ising and Heisenberg models, low-dimensional magnetism)
- Dipolar interaction in solids (shape anisotropy, dipolar frustration, origin of magnetic domains)

*Lecture notes*  
Learning material will be made available through a dedicated RStudioServer and through Moodle.

*Prerequisites / notice*  
Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism. Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

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**402-0595-00L**  
**Semiconductor Nanostructures**  
**W** 6 credits  **2V+1U**  
T. M. Ihn

*Abstract*  
The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

*Objective*  
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

*Content*  
1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k-p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

*Lecture notes*  
In addition to the lecture notes, the following supplementary books can be recommended:

The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>227-1871-00L</td>
<td>Semester Project ⬤</td>
<td>O</td>
<td>12 credits</td>
<td>20A</td>
<td>Supervisors</td>
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<td></td>
<td>Registration in myStudies required!</td>
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<tr>
<td></td>
<td>Supervisor must be a professor at D-ITET or D-PHYS, see <a href="http://master-qt.ethz.ch/education/semester-project.html">http://master-qt.ethz.ch/education/semester-project.html</a></td>
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</tbody>
</table>

Abstract
Semester projects are designed to train the students for independent scientific work. A project uses the student's technical and social skills acquired during the master's program. The semester project comprises 280 hours of work and is supervised by a professor.

Objective
see above

Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1873-00L</td>
<td>Internship in Industry ⬤</td>
<td>W</td>
<td>12 credits</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td>Only for Quantum Engineering MSc.</td>
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</tbody>
</table>

Abstract
The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

Objective
see above

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1873-10L</td>
<td>QuanTech Workshops ⬤</td>
<td>W</td>
<td>12 credits</td>
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<td>G. Raino, M. Frimmer</td>
</tr>
<tr>
<td></td>
<td>Only for Quantum Engineering MSc.</td>
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</tbody>
</table>

Abstract
Students practice development, planning, and execution of a project in the quantum engineering domain. By working in close collaboration with senior scientists and professors from the two departments D-ITET and D-PHYS, the goal is to provide solutions for pressing challenges in the field of quantum technologies.

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1800-00L</td>
<td>Master's Thesis ⬤</td>
<td>O</td>
<td>30 credits</td>
<td>68D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
The Master Program finishes with a 6-months Master Thesis which is directed by a Professor of the Department or a Professor of another Department who is associated with the D-ITET. Students gain the ability to conduct independent scientific research on a specific research problem.

Science in Perspective

see Science in Perspective: Type A: Enhancement of
### Quantum Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Basic Courses

### First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0241-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>M. Akveld</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Mathematical tools for the engineer</td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers. Mathematical formulation of technical and scientific problems.</td>
<td></td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>Complex numbers. Calculus for functions of one variable with applications. Simple Mathematical models in engineering.</td>
<td></td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Wird auf der Vorlesungshomepage zu Verfügung gestellt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Urs Stammbach, &quot;Analysis I/II&quot; (erhältlich im ETH Store); <a href="https://people.math.ethz.ch/~stammb/analysisskript.html">https://people.math.ethz.ch/~stammb/analysisskript.html</a></td>
<td></td>
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<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5 credits</td>
<td>3V+1U</td>
<td>M. Akka Ginosar</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to Linear Algebra</td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Basic knowledge of linear algebra as a tool for solving engineering problems. Together with Analysis we develop the basic mathematical knowledge for an engineer. The Modelling competency is taught, applied, and tested, and the Programming competency is applied.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces. Calculation with MATLAB will be introduced in the first exercise class.</td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>The lecturer will provide course notes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>K. Nipp, D. Stoffer, Linear Algebra, VdF Hochschulverlag ETH</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Literature</td>
<td>G. Strang, Linear Algebra, Springer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>252-0845-00L</td>
<td>Computer Science I</td>
<td>O</td>
<td>5 credits</td>
<td>2V+2U</td>
<td>C. Cotrini Jimenez, M. Fischer</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The course covers the basic concepts of computer programming.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs. In the course &quot;Computer Science I&quot;, the competency of programming is taught, applied and examined. Furthermore modeling is taught and applied.</td>
<td></td>
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<tr>
<td><strong>Content</strong></td>
<td>Variables, types, control structures, functions, scoping, recursion, object-oriented programming. The programming language is Python. The slides and lecture notes will be made available for download on the course website.</td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Learn to Code by Solving Problems A Python Programming Primer Daniel Zingaro Python Crash Course A Hands-On, Project-Based Introduction to Programming Eric Matthes</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>The study of computer science is complemented with in-depth mathematical and international examples.</td>
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</tr>
<tr>
<td>Taught competencies</td>
<td>Subject-specific Competencies Concepts and Theories</td>
<td>assessed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Method-specific Competencies Analytical Competencies</td>
<td>assessed</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Taught competencies</td>
<td>Personal Competencies Creative Thinking Critical Thinking</td>
<td>assessed</td>
<td></td>
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</tr>
<tr>
<td>103-0313-00L</td>
<td>Spatial Planning and Landscape Development</td>
<td>O</td>
<td>5 credits</td>
<td>4G</td>
<td>A. Grét-Regamey, Y. M. Räth, J. Van Wezemael</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The lecture introduces the main-features of spatial planning. Attended will be the subjects planning as a national responsibility, instruments of spatial planning, techniques for problem solving in spatial planning and the Swiss concept for national planning. The lecture is complemented with in-depth mathematical and international examples.</td>
<td></td>
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<tr>
<td><strong>Objective</strong></td>
<td>Die Studierenden kennen die Grundzüge der Raumplanung, ihre wichtigsten Instrumente und Problemlösungsverfahren. Sie können das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Übungsaufgaben umsetzen. Grundzüge der Raumplanung und ihre wichtigsten Instrumente kennenlernen - Erarbeiten der Fähigkeit, räumliche Probleme zu erkennen und Problemlösungsverfahren auf diese anzuwenden - Planung und Landmanagement als interaktiven Prozess kennenlernen und anwenden - Verstehen der mit Fläche und Boden verbundenen Potentiale, Nutzungen und Prozesse</td>
<td></td>
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</tbody>
</table>
Die Vorlesung deckt die Grundlagen der (Schweizerischen) Raumplanung und Landschaftsentwicklung ab:

- Was ist Raumplanung (Begriffe)
- Prinzipien der Raumplanung
- Die Raumplanung als staatliche Aufgabe - Raumordnungspolitik
- Instrumente der Raumplanung auf den Planungsebenen (u.a. Sachpläne und Konzepte, Richtplanung, Nutzungsplanung, Sondernutzungsplanung, Landumlegungsverfahren)
- Problemlösungsverfahren in der Raumplanung - systemtechnisches Vorgehen
- Das schweizerische Raumordnungskonzept

Der Schwerpunkt der Vorlesung liegt auf der Erläuterung der Raumplanung als Problemlösungsverfahren. Das dabei vermittelte theoretische Wissen wird direkt an einer konkreten, praxisorientierten Übungsaufgabe umgesetzt. Im Rahmen der Übung wird das Projektgebiet während einer Exkursion besucht.

Lecture notes
Prof. Dr. W.A. Schmid et al. (2006, Stand 2017): Raumplanung GZ - Eine Einführung für Ingenieurstudierende. IRL-PLUS, ETHZ

- Handouts of the lectures
- Exercises

Download: http://www.plus.ethz.ch/de/studium/vorlesungen/bsc/spatial_planning_and_landscape_development.html

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103-0214-00L Cartography Fundamentals

<table>
<thead>
<tr>
<th>O</th>
<th>5 credits</th>
<th>4G</th>
<th>L. Humi</th>
</tr>
</thead>
</table>

Abstract
Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

Objective
Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

Content
Definitions "map" and "cartography", map types, current tasks and situation of cartography, map history, spatial referncem systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critics.

Lecture notes
Will be distributed module by module.

Literature

Download: http://www.plus.ethz.ch/de/studium/vorlesungen/bsc/spatial_planning_and_landscape_development.html

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103-0116-00L Ecology and Soil Science

<table>
<thead>
<tr>
<th>O</th>
<th>3 credits</th>
<th>2G</th>
<th>S. Tobias</th>
</tr>
</thead>
</table>

Abstract
The main focus of the lecture are the basics of ecology and soil science. Students learn about the interdependence of organisms and environment, resource cycles, ecosystems as well as soil characteristics and genesis. The impact of human behavior on ecosystems and the problems of different land use are covered by the lecture, too.

Objective
- Erlangen eines Einblicks in ökologische Grundlagen
- Fähigkeit, die Folgen planerischen Handelns auf Ökosysteme abzuschätzen
- Verständnis für ökologische Prozesse und Wechselwirkungen
- Funktionen und Potentiale des Bodens verstehen

Content
Grundlagen der Ökologie
- Definition von Ökologie, Art, Habitat, Ökosystem, Umwelt
- Einfluss des Menschen auf das Ökosystem

Zusammenhang von Landschaft und Ökologie

- Ökologische Zusammenhänge für die praktische Anwendung (z.B. in Planungsprozessen)

Grundlagen der Bodenkunde
- Grundbegriffe, Definition von Boden, Bodentypen und wesentliche Kenngrössen
- Bodenwasserhaushalt (Bewässerung, Entwässerung)
- Bodenverdünnung und Erosion

Lecture notes
Lecture notes and slides (in German) can be downloaded from the PLUS homepage.

Download: https://irl.ethz.ch/de/education/vorlesungen/bsc/ecology_and_soil_science.html

Literature

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Additional Basic Courses
No offer in Autumn Semester.

Compulsory Courses

Examination Block 1
Number | Title | Type | ECTS | Hours | Lecturers  
--- | --- | --- | --- | --- | ---  
401-0243-00L | Analysis III | O | 3 credits | 2V+1U | M. Akka Ginosar  
  
Abstract
We will model and solve scientific problems with partial differential equations. Differential equations which are important in applications will be classified and solved. Elliptic, parabolic and hyperbolic differential equations will be treated. The following mathematical tools will be introduced: Laplace and Fourier transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Learning to model scientific problems using partial differential equations and developing a good command of the mathematical methods that can be applied to them. Knowing the formulation of important problems in science and engineering with a view toward civil engineering (when possible). Understanding the properties of the different types of partial differential equations arising in science and in engineering.

Content
Classification of partial differential equations
- Study of the Heat equation general diffusion/parabolic problems using the following tools through Separation of variables as an introduction to Fourier Series.
- Systematic treatment of the complex and real Fourier Series
- Laplace transform and it's uses to differential equations
- Study of the Laplace equation and general elliptic problems using similar tools and generalizations of Fourier series.
- Application of Laplace transform for beam theory will be discussed.
- Time permitting, we will introduce the Fourier transform.

Lecture notes
Lecture notes will be provided

Literature
large part of the material follow certain chapters of the following first two books quite closely.


The course material is taken from the following sources:

Stanley J. Farlow - Partial Differential Equations for Scientists and Engineers


Prerequisites / notice
Analysis I and II, insbesondere, gewöhnliche Differentialgleichungen.

103-0233-10L | Fundamentals of GIS | O | 6 credits | 5G | M. Raubal  
  
Abstract
Fundamentals of geographic information systems: spatial data modeling; metrics & topology; vector, raster and network data; thematic data; spatial statistics; system architectures; data quality; spatial queries and analysis; geovisualisation; spatial databases; labs with GIS software

Objective
Knowing theoretical aspects of geographic information regarding data acquisition, representation, analysis and visualisation. Knowing the fundamentals of geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects.

Content
- Einführung GIS & GIScience
- Konzeptionelles Modell & Datenschema
- Vektorgeometrie & Topologie
- Rastergeometrie und -algebra
- Netzwerke
- Thematische Daten
- Räumliche Statistik
- Systemarchitekturen & Interoperabilität
- Datenqualität, Unsicherheiten & Metadaten
- Räumliche Abfragen und Analysen
- Präsentation raumbezogener Daten
- Geodatenbanken

Lecture notes
Vorlesungspräsentationen werden digital zur Verfügung gestellt.

Literature

Taught competencies

Subject-specific Competencies
Concepts and Theories | assessed
Techniques and Technologies | assessed

Method-specific Competencies
Analytical Competencies | assessed
Decision-making | assessed
Media and Digital Technologies | assessed
Problem-solving | assessed

Social Competencies
Self-presentation and Social Influence | not assessed

Personal Competencies
Creative Thinking | not assessed
Critical Thinking | not assessed
Integrity and Work Ethics | not assessed
Self-awareness and Self-reflection | not assessed
Self-direction and Self-management | not assessed

103-0187-02L | Satellite Geodesy | O | 4 credits | 3G | G. Möller

Autumn Semester 2022
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

**Objective**

- Knowledge of the Earth Observation sensors, techniques, and methods
- Understanding of the fundamental principles of image acquisition and processing
- Familiarity with the principles of sensor-specific geometries and transformations

**Content**

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

**Abstract**

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

**Notes**

- Folien zu jedem Vorlesungsblock werden zur Verfügung gestellt.
- Die Lehrveranstaltung gibt einen Einblick in die heutige Erdbeobachtung mit dem folgenden skizzierten Inhalt:

**Literature**

Ausgewählte Literatur wird am Anfang der Vorlesung vorgestellt.

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**102-0675-00L  Earth Observation**

**Objective**

- Geography of the Earth and changing times - Understanding of rotation of the 2. Earth and changing times - Gravitation and changing times

**Content**

- Basics of the sensor-specific geometries
- Fundamentals of image acquisition
- Sensor-specific determination of environmental parameters

**Abstract**

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

**Objective**

- Knowledge of the Earth Observation sensors, techniques, and methods
- Understanding of the fundamental principles of image acquisition and processing
- Familiarity with the principles of sensor-specific geometries and transformations

**Content**

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

**Abstract**

This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavior. It then continues with macroeconomics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

**Objective**

After successful completion of the course you will be able to:

- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

**Content**

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

- Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?
- Market failure: What happens when prices give wrong signals?
- Labour market: How do supply and demand work in the labour market? What influences unemployment?
- National accounts: How big is the Swiss economy?
- Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?
- Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?
- Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

**Notes**

- No script available

**Literature**


**Prerequisites / notice**

- Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

**Objective**
- Beherrschung der Grundlagen der Parameterschätzung
- Erkennung von Problemen, die mit Parameterschätzungsmethoden gelöst werden können
- Im Stande sein, reale Problemstellungen auf die Parameterschätzungsmodelle abzubilden
- Befähigt sein, mit Messunsicherheiten umzugehen und Resultate in Bezug auf ihre Qualität / Unsicherheiten zu beurteilen
- Interdisziplinäre Anwendungsmöglichkeiten der Parameterschätzung erkennen

**Content**
- Unsicherheit / Messunsicherheit
- Verteilungen
- Varianzfortpflanzung
- Vermittlende Ausgleichung
- Allgemeine Ausgleichung
- Zusatzbedingungen und a priori Information

**Examination Block 3**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-1004-00L</td>
<td>Operations Research</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>S. Bütiokoer van Oordt</td>
</tr>
</tbody>
</table>

**Abstract**
This course provides an introduction to operations research methods in the fields of management science and economics. Requisite mathematical concepts are introduced with a practical, problem-solving perspective.

**Objective**
- Introduction to building and using quantitative models in a business / industrial environment
- Introduction to basic optimization techniques (Linear Programming and extensions, network flows, integer programming, dynamic and stochastic optimization)
- Understanding the integration of quantitative models into the managerial decision process

**Content**
The economic environment of today's companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative models and methods of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analysed and optimized using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:
- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

**Literature**
Any standard textbook in Operations Research is a useful complement to the course.

**Prerequisites / notice**
Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.
The world's growing population, changing demographics, and changing climate pose formidable challenges to humanity's ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth's growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.

More specifically upon completion of the course, you will have gained insight into:

- how to structure the large amount of information that is often associated with attempting to modify complex systems
- how to set goals and define constraints in the engineering of complex systems
- how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
- how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future
- how to assess values of benefits to stakeholders that are not in monetary units
- how to assess whether it is worth obtaining more information in determining optimal solution
- how to take a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture
- the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.

Content

The weekly lectures are structured as follows:

1. Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. A high-level overview of the main principles of System Engineering. An introduction to the example that we will be working with through most of the course. The expectations of your efforts throughout the semester.
2. Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3. Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4. Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5. Analysis – 1/5 – The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, display, weighting, and expected value.
6. Analysis – 2/5 – The idea behind the supply and demand curves and revealed preference methods.
7. Analysis – 3/5 – The concept of equivalence, including the time value of money, interest, life times and terminal values.
8. Analysis – 4/5 – The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Marginal rates of return and internal rates of return.
9. Analysis – 5/5 – How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10. Evaluation of solutions – Regardless how sophisticated an analysis is, it requires that decision makers stand back and critically evaluate the results. This week we discuss the aspects of evaluating the results of an analysis.
11. Operations research – 1/4 – Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. This week we discuss linear programming and the simplex method.
13. Operations research – 3/4 – How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
14. Operations research – 4/4 – How to set up and solve problems when there are multiple objectives.

The course uses a combination of qualitative and quantitative approaches. The quantitative analyses requires the use of Excel. An introduction to Excel will be provided in one of the help sessions.

The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.
Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company wide success.

The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project. Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

No. The lecture slides and other additional material will be available for download from Moodle a week before each class.

E lective Blocks

Geodesy and Satellite Navigation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0139-00L</td>
<td>Geodetic Data Analysis</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Scharner</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture provides knowledge about the planning, computation and analysis of geodetic networks, as well as the use of data analysis methods in geodesy in general. The necessary mathematical and statistical methods are presented and applied using examples from geodesy.</td>
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</tr>
<tr>
<td>Objective</td>
<td>After completing this course, the participants should be equipped with the necessary tools to plan, analyze and evaluate geodetic networks as well as to evaluate and analyze geodetic data in general. For typical geodetic tasks the participants should be able to provide concepts of solutions as well as to do the necessary programming work.</td>
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<tr>
<td>Content</td>
<td>Recapitulation of basics in statistics and probability theory (density and distribution functions, random variables, correlations, Monte Carlo simulation, hypothesis tests), linear and nonlinear least squares estimation, terrestrial and satellite-based observation equations, reference frames and transformations (global, local, astronomical), geodetic datum (free/constrained networks, full/partial trace minimization), quality control of geodetic methods (precision, reliability), robust estimation, time series analysis (decomposition, stochastic processes, parametric/nonparametric methods, regression models, spectral analysis and filtering, significance tests), basics of Kalman filtering (state space representation, Kalman equations, quality control)</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Literature</td>
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</tbody>
</table>

Global Satellite Navigation Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0135-01L</td>
<td>Global Satellite Navigation Systems</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>G. Möller</td>
</tr>
</tbody>
</table>
| Objective  | • Erlernen der theoretischen und praktischen Grundlagen der verschiedenen GNSS  
• Verstehen der wichtigsten Fehlerquellen und der unterschiedlichen Beobachtungsverfahren  
• Erkennen von Anwendungen der GNSS in der Vermessung, Positionierung, Navigation, GIS, im Geomonitoring und in den Erd- und Umweltwissenschaften  
| Content   | • Überblick über die verschiedenen GNSS (GPS, GLONASS, Galileo, Beidou, QZSS und INRSS)  
• Systemkomponenten, Signalstrukturen, Referenz- und Zeitsystemen und Beobachtungsgleichungen für Pseudorange- und Phasenmessungen der GNSS  
• Bildung von Differenzen und Linearkombinationen der ursprünglichen Beobachtungen  
• Fehlerquellen: Satellitenbahnen und -uhren, troposphärische und ionosphärische Refraktion, Antennenchippenzentr, relativistische Einflüsse, Mehrwegefekte und Messrauschen  
• Einblick in die Bedeutung der speziellen und allgemeinen Relativitätstheorie für die GNSS  
• Auswertestrategien und Beobachtungsverfahren sowie Methoden zur Lösung der Phasenmehrdeutigkeiten  
• Referenzstationsnetze und Dienste  
• Viele Anwendungsbeispiele  
• Praktische und rechnerische Übungen für die Erfassung und Auswertung der GNSS-Messungen |      |      |                   |

Digitisation and 3D Modelling

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0115-01L</td>
<td>Advanced topics in geodetic metrology with focus on approaches to 3d modelling of local real world environments with higher accuracy.</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>A. Wieser, N. Meyer</td>
</tr>
<tr>
<td>Abstract</td>
<td>By the end of this course, the students are able to create digital 3d models of the real world covering areas with an extension up to several 100 m with accuracies in the mm- to cm-level range. They can select the appropriate geodetic instruments or terrestrial laser scanners, plan and carry out the required working steps, test the equipment before use, and describe the quality of the results. They know a broad spectrum of visualization options and can assess their respective suitability for various application cases.</td>
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</tr>
</tbody>
</table>
| Objective  | Overview: 3D Modelling from planning of data acquisition to visualization of the results  
Modern geodetic instruments  
Atmospheric effects  
Measurement techniques for high accuracy  
Introduction to terrestrial laser scanning  
Test and calibration of measurement instruments  
Point cloud processing: preprocessing, registration & georeferencing  
3d modelling and visualization of objects, VR/AR/MR |      |      |                   |
| Content    | • Overview: 3D Modelling from planning of data acquisition to visualization of the results  
Modern geodetic instruments  
Atmospheric effects  
Measurement techniques for high accuracy  
Introduction to terrestrial laser scanning  
Test and calibration of measurement instruments  
Point cloud processing: preprocessing, registration & georeferencing  
3d modelling and visualization of objects, VR/AR/MR |      |      |                   |
| Lecture notes | The slides and documents for enhanced study and further reading will be provided online. |      |      |                   |
Prerequisites / notice
The course is carried out in German. Basic knowledge of geodetic metrology is required as a prerequisite, corresponding to the learning objectives and content of the course Geodätische Messtechnik GZ. Besides lectures and data processing, the course also comprises extensive practical exercises in the field.

GIS and Cartography

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0717-00L</td>
<td>Geoinformation Technologies and Analysis</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>M. Raubal</td>
</tr>
</tbody>
</table>

Abstract
Geoinformationstechnologien und -analysen für Fortgeschrittene: Mobile GIS; Web-GIS & Geo-Web-Services; Spatial Big Data; Zeitliche Aspekte in GIS; Analyse von Bewegungsdaten; Benutzerschnittstellen

Objective

Content
- Mobile GIS
- Web-GIS & Geo-Web-Services
- Spatial Big Data
- Zeitliche Aspekte in GIS
- Analyse von Bewegungsdaten
- Benutzerschnittstellen

Lecture notes
Vorlesungspräsentationen werden digital zur Verfügung gestellt.

Literature

Spatial and Environmental Planning

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0325-02L</td>
<td>Integrated Spatial Planning in Cities and Districts</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>G. Di Carlo Alvarez, F. Günther, R. Streit</td>
</tr>
</tbody>
</table>

Abstract
Methodische und instrumentelle Grundlagen der Raumentwicklung werden aus integrierter Sicht (Städtebau, Freiraum, Verkehr) vermittelt und von den Studierenden konkret in einem Zürcher Stadtquartier als Semesterübung angewendet.

Objective
Die Studierenden lernen:
- Ein Repertoire an hilfreichen Werkzeugen sowie Denkmuster aus der Raumplanung kennen
- Quartiere eigenständig zu erkunden, Potentiale sowie Risiken der Raumentwicklung zu erkennen und zu dokumentieren
- Eigene Räumliche Entwicklungskonzepte zu entwerfen und zu präsentieren
- Massnahmen für Schlüsselgebiete zu konkretisieren, u.a. hinsichtlich Zeitplanung, Organisation und Kosten

Content
Die Vorlesung vermittelt methodische und instrumentelle Grundlagen zu planerischen Denkmustern und Repertoire sowie Hilfestellungen für Entwerfen, Argumentieren und Entscheiden.

Lecture notes
Vorlesungsfolien und Unterlagen werden auf Moodle hochgeladen.

Traffic Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0415-01L</td>
<td>Public Transport and Railways</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Nash, H. Orth, S. Schranil</td>
</tr>
</tbody>
</table>

Abstract
Fundamentals of public and collective transport, in its different forms. Categorization of performance dimensions of public transport systems, and their implications to their design and operations.
Objective
Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.

Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspective and stakeholders.

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.

Content
Fundamentals: Infrastructures and vehicle technologies of public transport systems; interaction between track and vehicles; passengers and goods as infrastructure users; management and financing of networks.

Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings

Vehicles: Classification, design and suitability for different goals

Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.

Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity

Lecture notes
Slides, in English, are made available some days before each lecture.

Literature
Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td></td>
<td>Creative Thinking</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td></td>
<td>Critical Thinking</td>
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<td></td>
<td>Problem-solving</td>
<td></td>
<td>Integrity and Work Ethics</td>
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<tr>
<td></td>
<td>Project Management</td>
<td></td>
<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

Network Infrastructure

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0609-00L</td>
<td>Energy and Climate Design I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>A. Schlüter</td>
</tr>
</tbody>
</table>

Abstract
This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

Objective
At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=11917). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

Content
Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:
1. Local potentials
2. Demand estimation
3. Supply concepts

Lecture notes
Material on moodle serves as lecture notes.

Literature
A list of relevant literature is available at the chair and through moodle.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
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<td>Analytical Competencies</td>
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<tr>
<td>Techniques and Technologies</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

052-0701-00L | Urban Design I | W | 2 credits | 2V | M. Wagner |

Abstract
The means and potentials in the field of urban planning and design are pointed out from different perspectives in order to shape the city in the sense of a future-proof and humane environment. To this end, the basic principles are explained and concrete methods of urban design are presented.

Objective
The goal is to provide students with a broad systemic basic knowledge, that enables them to synthesize and evaluate complex urban design and planning problems.
The lecture series imparts basic knowledge in urban planning and design. Pressing questions and main topics of contemporary urban design practice and theory will be addressed. The focus is on illustrating the richness of relationships as well as the potential of the discipline and its handling in everyday urban planning and design practice.

There is no script to the lecture series. The lectures are recorded on video and made available online on [link](http://www.video.ethz.ch/lectures.html) a few days after each lecture.

At the end of the year course a reader with secondary literature will be made available for download.

**Electives**

**Electives ETH Zurich**

**Recommended Electives of Bachelor Degree Programme**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0241-00L</td>
<td>Cartography Lab 1</td>
<td>W</td>
<td>6 credits</td>
<td>13S</td>
<td>L. Hurni</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Independent practical work in cartography</td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Independent practical work in cartography</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>Choice of theme upon individual agreement</td>
<td></td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Cartography Fundamentals</td>
<td></td>
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</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Cartography II</td>
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<tr>
<td>103-0242-00L</td>
<td>Cartography Lab 2</td>
<td>W</td>
<td>8 credits</td>
<td>17S</td>
<td>L. Hurni</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Independent practical work in cartography</td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Independent practical work in cartography</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Choice of theme upon individual agreement</td>
<td></td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Information sheet will be distributed by the supervisors.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Cartography Lab 1</td>
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</tbody>
</table>

**Science in Perspective**

**Recommended Science in Perspective (Type B) for D-BAUG**

**Language Courses**

**Bachelor’s Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0006-10L</td>
<td>Bachelor’s Thesis</td>
<td>O</td>
<td>10 credits</td>
<td>21D</td>
<td>Supervisors</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Registration in myStudies by 15 January for theses during the spring semester, by 15 August for theses during the autumn semester.</td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work.</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>The contents base upon the fundamentals of the Bachelor Programme. Students can choose from different subjects and tasks. The thesis consists of both a written report and an oral presentation.</td>
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</tbody>
</table>

**Geospatial Engineering Bachelor - Key for Type**

| O   | Compulsory                                      |
| W+  | Eligible for credits and recommended            |
| W   | Eligible for credits                            |
| E   | Recommended, not eligible for credits           |
| Z   | Courses outside the curriculum                  |
| Dr  | Suitable for doctorate                          |

**Key for Hours**

| V   | lecture                                      |
| G   | lecture with exercise                         |
| U   | exercise                                      |
| S   | seminar                                      |
| K   | colloquium                                    |
| P   | practical/laboratory course                  |
| A   | independent project                           |
| D   | diploma thesis                                |
| R   | revision course / private study               |

Special students and auditors need special permission from the lecturers.
Further information and the documents for the lecture can be found on the homepage of IRL/STL.

Lecturer notes and slides as well as hints to further literature will be given during the course.

Spatial Planning and Development

Spatial development deals with the development, formation and arrangement of our environment. In order to be able to mediate between History, impact and principles of the design and operation of Landscape Planning and Environmental Systems

Concepts and Theories

The aims of this course are:

1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.

Lecture notes

Further information and the documents for the lecture can be found on the homepage of IRL/STL.

Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

Data: 18.08.2022 12:39
Autumn Semester 2022
Page 1896 of 2345
Content
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice
The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

Taught competencies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Decision-making</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Communication</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
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103-0377-10L Basics of RE&IS
Only for Spatial Development and Infrastructure Systems MSc.

Abstract
The course Basics of RE&IS provides essential knowledge for the Master's degree program in Spatial Development & Infrastructure Systems. It teaches the basics of technical-scientific work, such as scientific writing, literature review, and effective presentation and communication of results.

Objective
- Students will be able to identify, name, and define the content taught and understand the necessity, significance, and application of the standards in scientific work.
- Students will be able to apply the content, implement it in different examples and use it to solve the exercises and the semester assignment.
- Students develop a common understanding with regard to their methodological knowledge and can henceforth work scientifically at an appropriate level.
- With the techniques learned in the course, students will be able to
  - analyze and differentiate scientific sources and apply them in their work in a structured way
  - systematically compare and present their results in an argumentative manner
  - develop, formulate, and design a scientific report
  - produce results in collaboration with their group
  - present results in an engaging presentation with their group using attractive and formally correct visualizations, maps, or diagrams
  - discuss and give critical feedback in the form of peer-assessments of other students

Content
Students will learn the basics of scientific work and practice their skills within the framework of three separate exercises (formative) as well as an ungraded semester performance, which consists of two parts and will be worked out in groups of two to three students.

In the first half of the semester, students will learn the theoretical basics and apply and understand these in the context of the exercises. In the second half of the semester, the students will work on a written scientific report applying the methods learnt in the first half of the semester. The results of the report should be communicated in an effective and clear oral presentation taped on video. The final videos, as well as the exercises in the first part of the course will be discussed and evaluated among the students in class (peer-assessment).

- Exercise 1: Literature search & referencing
- Exercise 2: Scientific writing – report structure, paragraph structure, language style
- Exercise 3: Maps, Graphs & Visualizations
- Ungraded semester performance: consists of (1) written report on topic of interest and (2) oral presentation on video

Students will be supervised by the course instructors throughout the course. Furthermore, feedback and discussion opportunities will be given by other students by the principle of peer assessment.

The main course lead changes periodically between the following RE&IS chairs: Infrastructure Management (IM), Transportation Systems (TS), Traffic Engineering (SVT), Transport Planning (VPL), Spatial Development and Urban Policy (SPUR), Planning of Landscape and Urban Systems (PLUS) and Spatial Transformation Laboratories (STL).

Lecture notes
All documents relevant for the course (slides, literature, further links, etc.) are provided centrally via the Moodle platform.
Spatial planners ensure our built environment optimally meets our future needs. This course explains how spatial planners can evaluate proposed modifications to network infrastructure when there is substantial future uncertainty with respect to requirements, and how to develop implementation plans taking into consideration asset life cycles.

The course consists of 9 lectures, 2 projects and 5 help sections. The two hour weekly lecture period is used as follows:

- Appropriate literature will be handed out when required via Moodle.
- Help sessions 7-9 – We use the lecture periods to answer any questions you might have on project 1.
- Help sessions 13 and 14 – We use the lecture periods to answer any questions you might have on project 2.
- The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.
- The lecture materials consist of handouts, the slides, and example calculations in Excel.
- The lecture materials will be distributed via Moodle two days before each lecture.
- This course has no prerequisites.

The objective of this course is to provide spatial planners with an introduction to two essential tools in this regard. The first tool is a methodology to systematically take into consideration the future uncertainty in infrastructure requirements when proposing changes to the built environment. This involves the identification of key uncertainties, modelling their effect on infrastructure requirements and assessing how changes in future needs and the environment may affect future decisions. The second tool is a methodology to systematically estimate the life cycles of infrastructure assets. This methodology can be used together with the state of the existing infrastructure assets to develop optimal implementation plans.

More specifically, upon completion of the course students will understand how:

- to identify and quantify the service being provided by the built environment
- to construct an objective function to be used in the evaluation of proposed modifications to estimate changing societal needs and their potential effect on required infrastructure
- to develop concepts for flexible/robust infrastructure alongside traditional infrastructure
- to simulate future scenarios to evaluate the costs and effects on the service provided over time by infrastructure
- to estimate the service provided by existing infrastructure now and in the future
- to determine optimal maintenance strategies for infrastructure
- to convert them into optimal intervention programs, which can be used to build strong arguments as to when system modifications should be implemented.

The course consists of 9 lectures, 2 projects and 5 help sections. The two hour weekly lecture period is used as follows:

1. Planning infrastructure interventions – This lecture provides an introduction to the course and why it is useful in helping spatial planners propose and evaluate modifications to the built environment. The requirements for successful completion of the course are discussed and the two projects are introduced.
2. Service – Arguments for modifying the built environment are built on meeting the future needs of stakeholders. This week we present how to identify, quantify and value the service provided by the built environment. The measures of service, along with intervention costs are used to construct an objective function to be used in the evaluation of proposed modifications.
3. Changing needs – Trying to modify the built environment to meet future needs, requires estimating them. This week we discuss how to estimate them and their potential effect on required infrastructure.
4. Robust and flexible infrastructure – In the face of large ranges of future uncertainty it is useful to have either robust infrastructure, i.e. infrastructure that meets a large range of possible future needs, or flexible infrastructure, i.e. infrastructure that can be easily modified to meet different possible future needs. This week we discuss the concepts of robustness and flexibility and demonstrate their roles in maximizing the net-benefit of infrastructure.
5. Evaluating robust and flexible infrastructure – Robust and flexible infrastructure sometimes comes with increased costs. Whether or not the costs are worth it depends on a myriad of factors. This week we present a methodology that helps you develop robust and flexible infrastructure and evaluate their costs and benefits over time.
6. Simulating the uncertain future – As a key aspect to evaluating robust and flexible infrastructure is simulating what might happen in the future, this week, we explain how use Monte Carlo simulations and conduct an in class exercise so that you have an enhanced understanding of how it is done.
7. Help sessions 7-9 – We use the lecture periods to answer any questions you might have on project 1.
8. Maintenance strategies – It is useful to know the optimal maintenance intervention strategies for infrastructure assets when considering how to modify infrastructure to accommodate future needs, as it is easier to justify expenditures when a maintenance intervention is planned than immediately afterwards, when it is in a like new state. This week we explain how optimal intervention strategies are estimated.
9. Maintenance programs – As planning periods approach, exact decisions need to be made as to which interventions will be executed, taking into consideration network level constraints, such as budgets. This week we demonstrate how the state of assets together with the optimal maintenance strategies and network level constraints can be combined to determine optimal maintenance programs. These programs are used to optimally integrate both maintenance and modification interventions into one intervention program.
10. Help sessions 13 and 14 – We use the lecture periods to answer any questions you might have on project 2.
11. Help sessions 7-9 – We use the lecture periods to answer any questions you might have on project 1.
Introduction to the Programming Language R

Abstract
R is one of the most popular programming language in science and practice for data analysis, modelling and visualisation. In this course, you will learn the basics of R and some common applications of R, such as making plots, regression analysis and working with spatial data. The weekly computer labs start with a short lecture followed by exercises that have to be handed in to pass the course.

Objective
The overall objective of this course is to provide an introduction to the programming language R and to build confidence to apply R in other courses. More specifically, the objectives are:
- Understand how to import and export data, and how to work with the most important types of R-objects (e.g. vectors, data frames, matrices and lists).
- Learn how to create meaningful and visually attractive graphics and apply this knowledge to several datasets.
- Learn how to apply several types of important functions (e.g. for- and while-loops, if-else statements, data manipulation).
- Understand descriptive statistics and regression analysis and apply this knowledge to analyse several datasets.
- Understand the possibilities of analysing and plotting spatial data.
- Learn how to write own functions.

Content
The course has a strong focus on "learning by doing". During the weekly computer lab sessions, students will be given an introduction to the programming language R. Each lab session will start with a short introductory lecture, after which students work through the script and complete the exercises. During the lab sessions, the lecturers will be available to answer individual questions. The main topics that will be covered in the lab sessions are:
- importing and exporting data
- types of R-objects
- data scraping
- plotting data
- descriptive statistics
- data manipulation
- conditionals and loops
- regression analysis
- plotting and analyzing spatial data
- writing own functions

In the 7th and 14th week of the course, students have the time to finish the exercises that should be handed in at the end of those weeks.

Lecture notes
A script with theory, examples and exercises will be handed out at the beginning of the course. Data for the exercises will be made available via Moodle.

Literature

Prerequisites / notice
No prior knowledge of R or any other programming language is required for this course.

Major Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
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<td>103-0378-00L</td>
<td>Introduction to the Programming Language R</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>M. J. Van Strien, A. Grêt-Regamey</td>
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</table>

Abstract
R is one of the most popular programming language in science and practice for data analysis, modelling and visualisation. In this course, you will learn the basics of R and some common applications of R, such as making plots, regression analysis and working with spatial data. The weekly computer labs start with a short lecture followed by exercises that have to be handed in to pass the course.

Objective
The overall objective of this course is to provide an introduction to the programming language R and to build confidence to apply R in other courses. More specifically, the objectives are:
- Understand how to import and export data, and how to work with the most important types of R-objects (e.g. vectors, data frames, matrices and lists).
- Learn how to create meaningful and visually attractive graphics and apply this knowledge to several datasets.
- Learn how to apply several types of important functions (e.g. for- and while-loops, if-else statements, data manipulation).
- Understand descriptive statistics and regression analysis and apply this knowledge to analyse several datasets.
- Understand the possibilities of analysing and plotting spatial data.
- Learn how to write own functions.

In the 7th and 14th week of the course, students have the time to finish the exercises that should be handed in at the end of those weeks.

Lecture notes
A script with theory, examples and exercises will be handed out at the beginning of the course. Data for the exercises will be made available via Moodle.

Literature

Prerequisites / notice
No prior knowledge of R or any other programming language is required for this course.

Major Courses

Major in Spatial and Landscape Development

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<tr>
<th>Number</th>
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<td>103-0337-00L</td>
<td>Site and Project Development</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Gonzalez Martinez, J. Van Wezemael</td>
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Abstract
The focus of the lecture Site & Project Development is on larger contiguous areas or sites and their urban, open space and infrastructural development. In this course, students work on a semester exercise in which they “develop” a specific large-scale project from practice and evaluate it economically, strategically and in terms of feasibility.
Students in this course will pursue the following learning objectives:

- Investigate and understand a given concrete project area and identify, evaluate and articulate the current problems and relevant issues within this area.

- Consolidate their knowledge in the essential topics of site & project development and apply this in a well-founded, argued and creative manner to address the task at hand.

- Organize and structure themselves while acquiring responsibilities in their interdisciplinary project teams. The teams consist of three to five fellow students that must develop innovative, viable and resilient concepts for a real project development in a given area. Their considerations should be presented in written form (project report) and in linguistic-visual form (final presentation). At the end of the course, the students critically reflect on their experiences with the group work process together with the course instructors.

- Acquire methodological knowledge in location & market analysis, 3D visualization of a project as well as in the financial assessment of a large-scale real estate project and use this knowledge to justify their considerations and evaluate their proposal.

- Development and strengthening of their individual position as planners (spatial, urban, transport planners, etc.) in relation to the questions formulated in the proposed project within the field of Site & Development as well as within their own discipline.

The lecture is divided into several thematic sections analogous to the essential topics of Site & Project Development. The students are accompanied both in the semester exercise and in the individual lectures by a large number of external guest speakers from the praxis-field, which means that the lecture will not only thematically examine the relevant areas of Site & Project Development, but also will offer the students exclusive, practice-oriented insights. The relevant methodological knowledge for the semester exercise is imparted and, due to the proximity to practice, the students gain exclusive insights into possible professional fields of activity. In this lecture, students apply their already acquired and newly learned skills, especially in interdisciplinary teams, and work on an exciting, motivating and relevant question from the practice.

Major topics covered in the lecture include:
- Urban planning
- Location and market analysis
- Real estate development, financing and valuation
- Project development and decision-making from the perspective of investors
- Open space design and landscape architecture
- Sustainable building and sustainability certification
- Mobility, parking issues, travel models
- Cooperative planning and participation processes, mediation
- Gendered planning in project development
- Inner development & urban quality

Parallel to the lecture series, students work in interdisciplinary teams on a real-life task. In the course of the semester exercise, the lecture material is deepened and what has been learned is applied. The students visit the project area at the beginning of the semester as part of an excursion. Specific large-scale projects such as the Gaswerkareal Bern, the Stih-Manegg Areal Zurich (Greencity) or the Areal Alter Pilatusmarkt (Nidfeld) Lucerne will be dealt with. For the possible development of the given site, visions are developed by the students on the basis of a comprehensive location and market analysis and a utilization concept is developed. In the process, the students are accompanied by experts and regularly discuss their ideas and proposed solutions with their supervisors.

Lecture notes

- Handouts of the lectures
- Extracts from relevant scientific articles and theory literature
- Exercise material

Download: https://irl.ethz.ch/de/education/vorlesungen/msc/project_development.html

References in the lecture notes

none

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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<th>103-0417-02L</th>
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Abstract

This course deals with scientific and applied methods and the ways of thinking that are useful in planning practice as well as in scientific research. Students are offered interdisciplinary knowledge from planning practice and research, behavioural economics and social sciences. New perspectives on planning are opened up, which can lead to better results in future projects and research.
Objective
Keeping the general aim of exploring the basic methodologies in spatial planning research and practice, the specific course learning objectives are as follows:
- to address complex real-world spatial problems in adequate ways
- to know relevant theories and maxims that are subject to specific methods of problem solving
- to identify key questions and key concepts in contemporary planning research
- to select appropriate research methods to properly address the research questions

In practical terms, students:
- learn to deal with uncertainties and estimate quantities
- improve their ability to take decisions based on incomplete data and information
- are informed about different (qualitative and quantitative) methods and techniques for spatial research
- learn about different types of research (theoretical, empirical, action-oriented, qualitative, quantitative)
- get skilled for writing simple research essays
- are urged to question their own knowledge and challenge the course of action taken in planning processes

Content
The course is based on the following questions:

How do we deal with complex issues in planning?
- Forms of knowledge, half-knowledge and not knowing
- Occurrence and explanation patterns for irrational behaviour
- Spatial research and planning practice
- Planning maxims
- Mapping complex topics in research questions

How do we generate knowledge about complex issues?
- Methods for scientific data generation
- Applied handling of quantities and probabilities
- Estimating despite uncertainties
- Opportunities of digitisation in planning (Participation, BigData)

How do we react to complex questions in planning?
- Methods of scientific data analysis
- Making decisions despite incomplete information
- Dealing with robustness and fragility

More specifically, the lectures focus on the following topics (NB: Some content units will be presented in English, they are marked with *asterisk below)
- (Half-) knowledge/behaviour/irrationalities
- Initial situation: Solving complex problems
- Forms of knowledge, knowing of not knowing something, not knowing of not knowing something
- Behavioural patterns, occurrence and explanation patterns for irrational behaviour
- Methods for solving complex tasks in planning practice
- Spatial research and planning practice - connections, differences, overlaps
- Challenges in the solution of complex tasks: System delimitation, interdisciplinarity, retrospective vs. prospective approach (descriptive vs. action-oriented, "reflected scenario building")
- Planning maxims
- *Methodology in spatial research
- *Research design
- *Research questions (types of research questions; research questions, hypotheses and theories); justification of research question
- Data generation methods (interviews and questionnaires, ethnography and observation, documents, official statistics)
- Dealing with quantities, estimations, anchor effect
- Importance of scales and key figures in planning
- Estimation methods
- Danger of the anchor effect
- Digitization in planning
- New data sources and sizes
- Opportunities and challenges through digitisation in planning
- Data analysis methods (quantitative and qualitative data; quantitative analysis of survey data; qualitative analysis - content analysis, discourse analysis, case study, comparative research)
- *Research ethics
- *Decisions based on incomplete information
- Dealing with complex systems/roughness
- *Role of science in planning - the perspective of both research and practice

Lecture notes
Learning materials: available online (Moodle) before corresponding lecture.

Literature
Space Planning Law and Environment

W 2 credits  2G  O. Bucher

851-0707-00L

Subject-specific Competencies: Concepts and Theories (assessed), Techniques and Technologies (assessed).

Method-specific Competencies: Analytical Competencies (assessed), Decision-making (assessed), Media and Digital Technologies (assessed), Problem-solving (assessed), Project Management (assessed).

Social Competencies: Communication (assessed), Cooperation and Teamwork (assessed), Customer Orientation (assessed), Leadership and Responsibility (assessed), Self-presentation and Social Influence (assessed), Sensitivity to Diversity (assessed), Negotiation (assessed), Social Competencies: Communication (assessed), Cooperation and Teamwork (assessed), Customer Orientation (assessed), Leadership and Responsibility (assessed), Self-presentation and Social Influence (assessed), Sensitivity to Diversity (assessed), Negotiation (assessed).

Personal Competencies: Adaptability and Flexibility (assessed), Creative Thinking (assessed), Critical Thinking (assessed), Integrity and Work Ethics (not assessed), Self-awareness and Self-reflection (assessed), Self-direction and Self-management (not assessed).

Abstract
System of swiss planning law, Constitutional and statutory provisions, Space planning and fundamental rights, Instruments, Application, legal protection, enforcement, Practical training.

Objective
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

Literature
Hänni, Peter, Planungs-, Bau- und besonderes Umweltschutzrecht, 6.A., Bern 2016

History of Spatial Planning

W 3 credits  2V  M. Koll-Schretzenmayr

103-0327-00L

Abstract
This course aims to provide students with knowledge of the historical background to understand the current spatial structure and to face the current challenges in spatial planning. Social, cultural, and economic forces will be analyzed for the roles they have played in shaping the landscapes and cityscapes and the answers spatial planning had to spatial development. The course focuses on the history of planning ideas, paradigms and approaches. A link is made to current challenges in spatial planning. Students will critically discuss the challenges spatial planning is facing today.

Objective
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making

Lecture notes
Handouts will be available.

Literature

European Aspects of Spatial Development

W 3 credits  2G  A. Peric Momcilovic

103-0569-00L

Abstract
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective
Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making
### Content
- European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the role of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

### Literature
- The documents for the lecture will be provided at the moodle.

### Obligatory literature:

### Recommended literature:
- Governance models:

### Planning models:

### EU as a political context:

### Territorial cooperation in Europe:

### Planning families and cultures:

### Planning systems in Europe:

### Prerequisites / notice
- Only for master students, otherwise a special permission by the lecturer is required.

### Taught competencies

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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### Exercises
- The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

### Objective
- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies
Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.
### Objective

Students will be able to:
1. critically consider biological data books and local, regional, and national inventories;
2. evaluate the validity of ecological criteria used in decision making processes;
3. critically appraise the handling of ecological data and criteria used in the process of evaluation
4. perform an ecological evaluation project from the field survey up to the decision making and planning.

### Content

The course covers the basic history and theory of garden design and landscape architecture from its beginnings to the 21st century. The course aims to raise awareness of a changing perception of nature and landscape.

### Lecture notes

Powerpoint slides are available on the webpage. Additional documents are handed out as copies.

### Literature

Basic literature and references are listed on the webpage.

### Prerequisites / notice

The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

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### Course Details

<table>
<thead>
<tr>
<th>Code</th>
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<th>Type</th>
<th>Credits</th>
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<tr>
<td>052-0705-00L</td>
<td>Landscape Architecture I</td>
<td>W</td>
<td>2</td>
<td>C. Girot</td>
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<tr>
<td>103-0468-00L</td>
<td>Participatory Environmental Modeling</td>
<td>W</td>
<td>3</td>
<td>N. Salliou, B. Black</td>
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<tr>
<td>102-0317-00L</td>
<td>Advanced Environmental Assessments</td>
<td>W</td>
<td>3</td>
<td>S. Pfister</td>
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### Additional Information

- Bachelor students: The content of the lectures as well as texts and exam-relevant literature provided by the Chair make up the basis for preparing for the exam. The lecture series is conceived as a yearlong course. Since the written session examination will test knowledge from both semesters, it is necessary to fully attend the lectures of both courses "Landscape Architecture I" and "Landscape Architecture II". The themes of the examination will be announced at the end of the semester. The Chair will provide literature and texts available for download as pdfs. These allow a more in-depth understanding of the lecture material.

- Exchange students or students from other departments: Students, who are attending only one semester, may pass the oral end-of-semester examination. Test-relevant literature will also be made available for download for this purpose.

- The students are requested to get in touch by email with the Chair.

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### Taught competencies

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Taught Competencies</th>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Cooperation and Teamwork</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
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### Data

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1905 of 2345
Objectives
This course has the aim of deepening students' knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the
- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

Content
- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

Lecture notes
No script. Lecture slides and literature will be made available on Moodle.

Literature
Literature will be made available on Moodle.

Prerequisites / notice
Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
assessed
Media and Digital Technologies
not assessed

Problem-solving
assessed

Personal Competencies
Critical Thinking
assessed


Abstract
This course conveys an introduction into methods of urban research in social sciences through lectures and accompanying exercises. It treats the basic principles of scientific research, literature research, different forms of participant observation, qualitative interviews (expert interviews and ethnographic interviews), and the analysis of urban qualities.

Objective
This course aims at enabling students of architecture to use sociological analysis as basis for concrete projects in architecture and urban design. It is based on a specific set of methods that is applied in design studios (integrated disciplines) as well as in the master thesis (supplementary discipline sociology).

Major in Transport Systems and Behaviour

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tr>
<td>101-0427-01L</td>
<td>Public Transport Design and Operations</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>F. Corman, T.-H. Yan</td>
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</table>

Abstract
This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.

Objective
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
- general introduction of transport, modes, technologies,
- system design and line planning for different situations,
- mathematical models for design and line planning,
- timetabling and tactical planning, and related mathematical approaches
- operations, and quantitative support to operational problems,
- evaluation of public transport systems.

Content
Basics for line transport systems and networks
- Passenger/Supply requirements for line operations
- Objectives of system and network planning, from different perspectives and users, design dilemmas
- Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations
- Matching demand and modes
- Line planning techniques
- Timetabling principles

Allocation of resources
- Management of operations
- Measures of realized operations
- Improvements of existing services

Lecture notes
Lecture slides are provided.
Taught competencies

### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

### Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Literature
- Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

### Abstract
In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation. The program is taught in English and we provide 11 different experts/lecturers. The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport. The course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

### Content
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

### Lecture notes
Preparation materials & slides are provided prior to each class

### Literature
Preparation materials & slides are provided prior to each class

### Prerequisites / notice
The lecture is planned as class teaching.

### 101-0417-00L Transport Planning Methods
W 6 credits 4G K. W. Axhausen

### Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.
Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problems
- Getting familiar with cost-benefit analysis as a decision-making tool

Content
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Lecture notes
Moodle platform (enrollment needed)

Literature

Abstract
Fundamentals of traffic flow theory and control.

Objective
The objective of this course is to fully understand the fundamentals of traffic flow theory in order to effectively manage traffic operations. By the end of this course students should be able to apply basic techniques to model different aspects of urban and inter-urban traffic performance, including congestion.

Content
Introduction to fundamentals of traffic flow theory and control. Includes understanding of traffic data collection and processing techniques, as well as data analysis, traffic modeling, and methodologies for traffic control.

Lecture notes
The lecture notes and additional handouts will be provided during the lectures.

Literature
Additional literature recommendations will be provided during the lectures.

Prerequisites / notice
Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)
Special permission from the instructor can be requested if the student has not taken Verkehr III
The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.
Objective

The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:

- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:

1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:

1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/ extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and present) across the semester. A mid-term and final presentation of the work will be asked from each group of students.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Lecture notes

The lecture notes and additional handouts will be provided before the lectures.

Literature

Additional literature recommendations will be provided at the lectures.

Prerequisites / notice

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

101-0491-00L

Agent Based Modeling in Transportation

W 6 credits 4G M. Balac

Abstract

This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

Objective

At the end of the course, the students should:

- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform practical transportation studies

Content

This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

Literature

Agent-based modeling in general
MATSim

Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

Prerequisites / notice

There are no strict conditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

101-0469-00L

Road Safety

W 6 credits 4G M. Deublein, P. Eberling

Abstract

The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

Objective

Improving knowledge base about road safety and the event of accident, presenting possibilities to increase road safety

Content

Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy

Literature

Further literature: will be presented during the course

101-0491-10L

Basics of Java and Best Practices for Scientific Computing

W 1 credit 1U M. Balac

Abstract

This course provides an introduction to programming in Java, version control, and cloud computing.
### Major in Network Infrastructure

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<thead>
<tr>
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<th>Title</th>
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<td>101-0549-00L</td>
<td>Selected Topics on Legal Aspects in Civil Engineering</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>H. Briner, D. Trümppy</td>
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<td></td>
<td>Basic knowledge in public and private law of civil engineering. Examples of the subjects treated: space management, protection of the environment, legal procedures, standards for building technology and contracts.</td>
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<td>Objective</td>
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<tr>
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<td>- Have acquired object-oriented programming skills with a focus on Java.</td>
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<td>- Have an understanding of version control using git</td>
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<td>- Have learned to deploy Java applications on servers</td>
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<td>Content</td>
<td>This course provides an introduction to object-oriented programming with Java. Four topics are covered:</td>
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<td>- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...)</td>
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<td></td>
<td>- Injection (traditional vs. Guice)</td>
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<td>- Code versioning</td>
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<td></td>
<td>- Java application deployment on servers</td>
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<tr>
<td>Literature</td>
<td>Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang</td>
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### Microscopic Modelling and Simulation of Traffic Operations

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<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Makridis</td>
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<td>Abstract</td>
<td>The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies.</td>
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<td>- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.)</td>
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<td></td>
<td>- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.</td>
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<tr>
<td>Content</td>
<td>In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.</td>
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<td></td>
<td>Microscopic modelling and simulation concepts will include:</td>
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<tr>
<td></td>
<td>1) Car following models</td>
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<td></td>
<td>2) Lane change models</td>
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<td></td>
<td>3) Calibration and validation methodology</td>
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<td>Specific tasks for the project will include:</td>
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<tr>
<td></td>
<td>1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.</td>
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</tr>
<tr>
<td></td>
<td>2) Calibrating and validating the simulation model</td>
<td></td>
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<tr>
<td></td>
<td>3) Redesigning/extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.</td>
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<tr>
<td></td>
<td>The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students.</td>
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<tr>
<td></td>
<td>It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.</td>
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<tr>
<td></td>
<td>The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.</td>
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</tr>
<tr>
<td>Literature</td>
<td>The lecture notes and additional handouts will be provided before the lectures.</td>
<td></td>
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</tr>
<tr>
<td>Prequisites /</td>
<td>Additional literature recommendations will be provided at the lectures.</td>
<td></td>
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</tbody>
</table>

### Road Safety

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0489-00L</td>
<td>Road Safety</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>M. Deublein, P. Eberling</td>
</tr>
<tr>
<td>Abstract</td>
<td>The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.</td>
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<tr>
<td>Objective</td>
<td>Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy</td>
<td></td>
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</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1911 of 2345
The lecture gives a deeper insight into track geometry including clearance profile, the interaction between track and vehicles as well as in construction and dimensioning of the track. Methods for the diagnosis of the state of the track and its forecast are shown. State-of-the-art maintenance strategies and technologies are presented.

1 - Track geometry
Track geometry including calculation and measuring as well as related data systems; clearance profiles

2 - Interaction
Interaction between track and vehicles, vehicle dynamics

3 - Railway Track
Stress; track construction including special features of railway bridges and tunnels

4 - Environmental aspects in track construction
Fundamentals; noise protection; vibration protection

5 - Diagnostics, maintenance strategies
Track diagnostics and forecast; maintenance strategies

6 - Track maintenance
Fundamentals of track maintenance and related methods

Lecture notes
The slides will be made available.


Literature
A list with related technical literature will be handed out.

Prerequisites / notice
Prerequisite: 101-0419-01 Railway Infrastructures 1 (FS)

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**Major Courses for all Majors**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0541-00L</td>
<td>Systems Dynamics and Complexity</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>F. Schweitzer</td>
</tr>
</tbody>
</table>

**Abstract**
Finding solutions: what is complexity, problem solving cycle.

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

**Objective**
A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

**Content**
Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.

The course is structured along three main tasks:
1. Finding solutions
2. Implementing solutions
3. Controlling solutions

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see "Prerequisites").

**Lecture notes**
The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture

**Interdisciplinary Project Work**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0020-00L</td>
<td>Interdisciplinary Project</td>
<td>O</td>
<td>16</td>
<td>34A</td>
<td>K. W. Axhausen</td>
</tr>
</tbody>
</table>

**Number**
Only for Spatial Development and Infrastructure Systems MSc, Programme Regulations 2021.
The Interdisciplinary Project Activity (IPA) forms the key feature of the MSc RE&IS. Students work on an interdisciplinary task from the field of spatial development and infrastructure systems in a real application area. The focus of the IPA on interdisciplinary cooperation and strong communication skills are crucial expertise required in practice to communicate with and between relevant actors.

Upon completion of the IPA, students have developed skills in:

1) Investigating and understanding a given project area in a real-world context as well as identifying, evaluating and formulating the current issues and relevant topics within that area.

2) Creating, designing/developing and evaluating an overall integrated strategy for the project area with relevant measures as well as an in-depth study of a certain area or topic within the project area visualizing, describing, presenting and reporting on these in a written project report.

3) Organising, structuring and promoting team work within an interdisciplinary group of 4-5 students in self-responsibility.

4) Applying previously learnt interdisciplinary methodological and theoretical skills from different fields as well as methods and design thinking learnt during the IPA.

5) Evaluating and choosing the right way of representation (e.g.: text, statistics, images, etc.) for all pieces of information, ideas and proposals throughout the whole semester.

6) Understanding, developing and strengthening and critically self-evaluating their individual disciplinary position and role.

Students apply the full range of their previously learned theoretical and methodological skills to solve the task together in their project team. Working closely with representatives of the case study area (e.g. officials, the wider public, different experts and decision-makers), which changes annually, as well as other experts, through site visits, and through individual mentoring by the six RE&IS chairs, students work in a stimulating and motivating environment to solve real-world spatial challenges.

- The project begins with a site visit of the project area at the beginning of the semester and the identification as well as precise formulation of the issues and opportunities observed within the project area.

- The students work on a complex, rather rough task and define their exact objective independently on the basis of the as-is analysis. In the overall strategy, the future development direction for the project area is then determined and measures are formulated to steer the development in this direction. Within a focus area or focus topic, students further develop their project and deepen their overall strategy. They test and evaluate the impact of selected measures and finally reflect on their project, summarize the most important findings and make a recommendation formulated to decision-makers.

- The project gets developed in an interdisciplinary group of students. The internal structuring of the group and distribution of work is to be organised by the students themselves.

- The choice of software for the project development is up to the students. The software used should be applicable to data analysis, information processing, image production and word processing. This can include the Adobe programs such as InDesign, Illustrator or Photoshop, GIS, the Microsoft programs such as Word, PowerPoint or Excel, CAD, R, etc.)

### Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0010-10L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>20</td>
<td>43D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Before starting the Master's thesis, students must have:

- a. obtained the Bachelor's degree;
- b. fulfilled all specified admission conditions, if any;
- c. acquired at least 90 credits in the Master's programme, including the credits in the mandatory courses and 12 credits in the area of the interdisciplinary project.

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce a scientifically structured work.

To work independently and to produce a scientifically structured work.

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

### Master Studies (Programme Regulations 2009)

#### Major Courses

##### Major in Spatial and Landscape Development

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0468-00L</td>
<td>Participatory Environmental Modeling</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>N. Salliou, B. Black</td>
</tr>
</tbody>
</table>

The lecture accompanies students into a participatory modelling process. We explore environmental topics such as urban agriculture or climate-resilient city. Students will get to know participatory modelling tools as well as concepts and approaches related to it. Students elaborate the processes from questions to interactive operational models.

In this course students will learn:

- The process of developing a model to address an environmental problem: from choosing an appropriate technique (Agent-based modelling, Bayesian Networks and System dynamics), to conceptualization and model building.

- Communication and facilitation skills to foster effective and legitimate collaboration with stakeholders.

Students then apply this knowledge and skills to a real-life case study, creating a model with stakeholders to address an environmental problem.
T. Netland

Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

Prerequisites / notice
Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

052-0801-00L Global History of Urban Design I

Abstract
This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

Objective
In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01. The History and Theory of the City as Project
02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03: The Idea of the Polis: Rome, Greece and Beyond
04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
09: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
010: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
011: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

Content
3 credits
2 credits
2G
T. Avermaete

Lecture notes
There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

Major in Transport Systems and Behaviour

363-0445-00L Production and Operations Management

Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

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The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM, Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Taught competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Project Management</td>
<td>not assessed</td>
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</tr>
<tr>
<td>Taught competencies</td>
<td>Communication</td>
<td>not assessed</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Customer Orientation</td>
<td>not assessed</td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Negotiation</td>
<td>not assessed</td>
<td>Adaptable and Flexibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>

### 101-0491-00L Agent Based Modeling in Transportation

**W 6 credits 4G M. Balac**

<table>
<thead>
<tr>
<th>Abstract</th>
<th>This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.</th>
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</thead>
<tbody>
<tr>
<td>Objective</td>
<td>At the end of the course, the students should:</td>
</tr>
<tr>
<td></td>
<td>- have an understanding of agent-based modeling</td>
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<td>- have an understanding of MATSim</td>
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<td>- have an understanding of the process needed to set up an agent-based study</td>
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<td></td>
<td>- have practical experience of using MATSim to perform practical transportation studies</td>
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<tr>
<td>Content</td>
<td>This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:</td>
</tr>
<tr>
<td></td>
<td>1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling</td>
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<td></td>
<td>2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zürich and T.U. Berlin, and its various parts</td>
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<td></td>
<td>3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open-source eqasim framework used at ETH Zürich to set up agent-based models will be introduced</td>
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<tr>
<td></td>
<td>4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.</td>
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<tr>
<td>Literature</td>
<td>During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).</td>
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<tr>
<td></td>
<td>Agent-based modeling in general</td>
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<td>MATSim</td>
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<td></td>
<td>Additional relevant readings, primarily scientific articles, will be recommended throughout the course.</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>There are no strict prerequisites regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.</td>
</tr>
<tr>
<td>Crash course</td>
<td>101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.</td>
</tr>
</tbody>
</table>

### 101-0469-00L Road Safety

**W 6 credits 4G M. Deublein, P. Eberling**

<table>
<thead>
<tr>
<th>Abstract</th>
<th>The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.</th>
</tr>
</thead>
</table>
| Objective | Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety
Content
Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy

Literature

Further literature: will be presented during the course

101-0492-00L Microscopic Modelling and Simulation of Traffic Operations

Objective
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a baseline scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the baseline scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the baseline scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Extra:

Content
In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun.

Microscopic modelling and simulation concepts will include:
1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/extend the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students.

Lecture notes and additional handouts will be provided before the lectures.

Lecture notes
The lecture notes and additional handouts will be provided before the lectures.

Literature
Additional literature recommendations will be provided at the lectures.

Prerequisites / notice
Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

401-0647-00L Introduction to Mathematical Optimization

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest path, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature
Further literature: will be presented during the course

Prerequisites / notice
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

101-0941-10L Basics of Java and Best Practices for Scientific Computing

Abstract
This course provides an introduction to programming in Java, version control, and cloud computing.

Objective
At the end of the course, the students should:
- Have acquired object-oriented programming skills with a focus on Java.
- Have an understanding of version control using git
- Have learned to deploy java applications on servers

Content
This course provides an introduction to object-oriented programming with Java. Four topics are covered:
- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...).
- Injection (traditional vs. Guice).
- Code versioning
- Java application deployment on servers

Literature
Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

Major in Network Infrastructure

Number Title Type ECTS Hours Lecturers
101-0258-00L River Engineering W 3 credits 2G V. Weitbrecht, I. Schalko, K. Sperger

Abstract
The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.
Objective
At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content
The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Lecture notes
Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

Literature
1. «Flussbau» lecture notes of fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance)
2. Erosion and Sedimentation; Pierre Y. Julien
3. River Mechanics; Pierre Y. Julien

Prerequisites / notice
Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Problem-solving assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed

Personal Competencies
Creative Thinking not assessed
Critical Thinking assessed
Self-direction and Self-management not assessed

101-0469-00L Road Safety W 6 credits 4G M. Deublein, P. Eberling
Objective
Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety.

Content
Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

Literature
Further literature: will be presented during the course

101-0492-00L Microscopic Modelling and Simulation of Traffic Operations W 3 credits 2G M. Makridis
Objective
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network.

Content
Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy

Literature
Further literature: will be presented during the course

101-0469-00L Road Safety W 6 credits 4G M. Deublein, P. Eberling
Objective
The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

Content
Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety.

Literature
Further literature: will be presented during the course
Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new Railway Infrastructures, Track geometry including calculation and measuring as well as related data systems; clearance profiles; interaction between track and vehicles, vehicle dynamics, stress; track construction including special features of railway bridges and tunnels; environmental aspects in track construction; track diagnostics and forecast; track maintenance and related methods. The course will be based on a project that each group of students will build (design, calibrate, analyze and present) across the semester. A mid-term and final presentation of the work will be asked from each group of students.

It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The group project with microscopic traffic simulator Aimsun.

Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/ extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Additional literature recommendations will be provided at the lectures.

Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with their meaning and use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The fourth part covers the methods used to reassess existing structures based on new information.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The fourth part covers the methods used to reassess existing structures based on new information.
Literature


S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

Prerequisites / notice

Basic course on probability theory and statistics

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0010-00L</td>
<td>Master's Thesis Only for Spatial Development and Infrastructure Systems MSc, Programme Regulations 2009.</td>
<td>O</td>
<td>24 credits</td>
<td>51D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Before starting the Master's thesis, students must have

a. obtained the Bachelor's degree;

b. fulfilled all specified admission conditions, if any;
c. acquired at least 90 credits in the Master's programme, including the credits in the mandatory courses and 12 credits in the area of the interdisciplinary project.

Abstract

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective

To work independently and to produce a scientifically structured work.

Content

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

Electives

The entire course programs of ETH Zurich and University Zurich are open to the students to individual selection. The students have themselves to check whether they meet the admission requirements for a course.

Recommended Electives of Master Degree Programme

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>103-0227-00L</td>
<td>Application Development in Cartography W</td>
<td>6 credits</td>
<td>4G</td>
<td>L. Hurni</td>
<td></td>
</tr>
</tbody>
</table>

Abstract

This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Objective

Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.

Content

- 3D cartography
- Web mapping
- Data processing
- Animations and interactions
- Map and UI design
- Web application development
- Programming (JavaScript).

Lecture notes

Handouts of the lectures and exercise documents are available on Moodle.

Prerequisites / notice

Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

Taught competencies

Subject-specific Competencies

Method-specific Competencies

Social Competencies

Personal Competencies

Techniques and Technologies assessed

Analytical Competencies assessed

Media and Digital Technologies assessed

Problem-solving assessed

Project Management assessed

Cooperation and Teamwork assessed

Critical Thinking assessed

Self-direction and Self-management assessed

Environmental Management

W 2 credits 2G R. Züst

Abstract

An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

Objective

Overview on environmental management and environmental management systems, general methods and principles.

Content

Introduction to environmental management / environmental management systems, energy and material flows; economical and ecological problems in industry; characterisation of an enterprise (incl. management handbook); structur and contents of an environmental management system; overview on the ISO 14001 ff. series; methods for environmental evaluation and assessment; integrated management systems; planning methodology and life-cycle-design design; planning example.

Lecture notes

Information about environmental management and environmental management systems will be provided by a CD or mail.

Literature

a list with literatures and links will be provided

Prerequisites / notice

Delivery of a case study, worked out in groups. Language: Teaching in English on request.

Private Construction Law

W 2 credits 2V T. Ender, E. Rüegg

Abstract

This class introduces to practice-relevant basics of construction and real estate law.

Objective

Understanding of important legal aspects for the construction practitioner.
Introduction (most important sources of construction and real estate law), SIA (Swiss Society of Engineers and Architects) Design Engineering Services Contract, SIA-Norm 118 (SIA General Terms and Conditions for Construction Services), liability of designers/civil engineers, construction insurance, property law for civil engineers, sale of land, contaminated sites, statutory mortgage for contractors, public procurement, litigation in construction and real estate, the civil engineer as expert, what else to know...

Lecture notes
There are ‘Lecture Notes’ (in German) for this course.

401-0647-00L Introduction to Mathematical Optimization W 5 credits 2V+1U D. Adjaishvili

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modeling with mathematical optimization: applications of mathematical programming in engineering.

Literature
Information about relevant literature will be given in the lecture.

Prerequisites / notice
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

363-0445-00L Production and Operations Management W 3 credits 2G T. Netland, H. Franke

Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:
1. Students can apply key concepts of POM to develop an operations strategy.
2. Students can design forecasting demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Content
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitalization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Literature
Suggested literature is provided in the syllabus.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Principles of Natural Hazard Management W 3 credits 4G V. Griess, A. Mathys

Abstract
This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk, and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.
By the end of the course, students will be able to:

- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.
- develop, formulate and present solutions to these challenges to a critical audience.

Literature

will be distributed and available on Moodle

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Module</th>
<th>Credits</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W</td>
<td>3 credits</td>
<td>J.-E. Sturm</td>
</tr>
<tr>
<td>101-0187-00L</td>
<td>Structural Reliability and Risk Analysis</td>
<td>W</td>
<td>3 credits</td>
<td>S. Marelli</td>
</tr>
<tr>
<td>052-0801-00L</td>
<td>Global History of Urban Design I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
</tr>
</tbody>
</table>

Abstract

- Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

Literature

There are three books that will function as main reference literature throughout the course:

1. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
2. Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
3. Garden Cities of Tomorrow: From the Global North to the Global South and Back Again

These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

Prerequisites / notice

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).
Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature
The set-up of the course will closely follow the book of N. Gregory Mankiw and Mark P. Taylor (2020), Economics, Cengage Learning, Fifth Edition. This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

401-3901-00L Linear & Combinatorial Optimization

Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature

Prerequisites / notice
Solid background in linear algebra.

Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed
Analytical Competencies

The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

Objective

At the end of the course, the students will be able to:

- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Lecture notes / literature

Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

1. «Flussbau» lecture notes of fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance)

2. Erosion and Sedimentation; Pierre Y. Julien

3. River Mechanics; Pierre Y. Julien

Prerequisites / notice

Recommended lectures:

Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Subject-specific Competencies

<table>
<thead>
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<th>Taught competencies</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td>Communication</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

052-0707-00L Urban Design III

Students are introduced to a narrative of 'Urban Stories' through a series of three tools driven by social, governance, and environmental concepts. The lecture series translates urban knowledge into operational tools, extracted from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, personal competencies into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

Abstract

How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instabiltiy present in the contemporary city and understand how urban form evolved to its current state.

Objective

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

Content

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.
### Literature

**103-0687-00L Cadastral Systems**

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
</table>
| Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society. | Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre and spatial data infrastructures. The link between cadastral systems, gender equality, economic prosperity and the contribution to the achievement of the United Nation Sustainable Development Goals (UN SDG) is discussed. The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples. | Origin and purpose of cadastral systems  
Importance of documentation of property information  
Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)  
Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment  
Swiss cadastral system  
- legal basis  
- organisation  
- Technical implementation  
- Quality and integrity assurance  
- profession  
- Embedding cadastral data in the national spatial data infrastructure  
Digital revolution and access to data  
Benchmarking and evaluations  
International trends, developments and initiatives to strengthen property rights |
Adlington, G. (2021): Real Estate Registration and Cadastre - Practical Lessons and Experiences  
Subject-specific Competencies  
Concepts and Theories  
Techniques and Technologies  
Social Competencies  
Cooperation and Teamwork  
Sensitivity to Diversity  
Personal Competencies  
Critical Thinking |

### Electives ETH Zurich

**Course Catalogue of ETH Zurich**

### Science in Perspective

**Recommended Science in Perspective (Type B) for D-BAUG**

**Course Units for Additional Admission Requirements**

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0031-AAL</td>
<td>Systems Engineering</td>
<td>E-</td>
<td>4</td>
<td>9R</td>
<td>B. T. Adey</td>
</tr>
</tbody>
</table>

**Abstract**

- Systems Engineering is a way of thinking that helps engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms.
- This course provides an overview of the main principles of Systems Engineering, and includes an introduction to the use of operations research methods in the determination of optimal systems.
The world’s growing population, changing demographics, and changing climate pose formidable challenges to humanity’s ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth’s growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.

More specifically upon completion of the course, you will have gained insight into:

• how to structure the large amount of information that is often associated with attempting to modify complex systems
• how to set goals and define constraints in the engineering of complex systems
• how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
• how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future
• how to assess values of benefits to stakeholders that are not in monetary units
• how to assess whether it is worth obtaining more information in determining optimal solution
• how to take a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture
• the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.

Content

The weekly content is structured as follows:

1. Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms. A high-level overview of the main principles of System Engineering. An introduction to the example that we will be working with through most of the course. The expectations of your efforts throughout the semester.
2. Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3. Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4. Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5. Analysis – 1/5 – The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, display, weighting, and expected value.
6. Analysis – 2/5 – The idea behind the supply and demand curves and revealed preference methods.
7. Analysis – 3/5 – The concept of equivalence, including the time value of money, interest, life times and terminal values.
8. Analysis – 4/5 – The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Marginal rates of return and internal rates of return.
9. Analysis – 5/5 – How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10. Evaluation of solutions – Regardless how sophisticated an analysis is, it requires that decision makers stand back and critically evaluate the results. This week we discuss the aspects of evaluating the results of an analysis.
11. Operations research – 1/4 – Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. This week we discuss linear programming and the simplex method.
13. Operations research – 3/4 – How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
14. Operations research – 4/4 – How to set up and solve problems when there are multiple objectives.

The course uses a combination of qualitative and quantitative approaches. The quantitative analyses require the use of Excel. An introduction to Excel will be provided in one of the help sessions.

Lecture notes

The script for the original course is in German. The English material that can be used for the virtual course is:

The literature will be made available at the beginning of the course.

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
**Abstract**
General introduction to the development, the life cycle and the characteristics of projects. Introduction to, and experience with, the methods and tools to help with the preparation, evaluation, organisation, planning, controlling and completion of projects.

**Objective**
To introduce the methods and tools of project management. To impart knowledge in the areas of project organisation and structure, project planning, resource management, project controlling and on team leadership and team work.

**Content**
- From strategic planning to implementation (Project phases, goals, constraints, and feasibility)
- Project leadership (Leadership, Teams)
- Project organization (Structure)
- Project planning (Schedule, cost and resource planning)
- Project controlling
- Risk and Quality Management
- Project completion

**Taught competencies**
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Personal Competencies
Critical Thinking assessed

**103-0313-AAL Spatial Planning and Landscape Development**
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Objective
- To get to know the interaction between the community and our living space and their resulting conflicts.
- Link theory and practice in spatial planning.
- To get to know instruments and facilities to process problems in spatial planning.

**103-0414-AAL Transport Basics**
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Objective
- Introduction to the fundamentals of transportation
- Developing an understanding of the interactions between land use and transportation
- Introduction to the dynamics of transport systems: daily patterns and historical developments

Content
- Accessibility
- Equilibrium in transport networks
- Fundamental transport models
- Traffic flow and control
- Vehicle dynamics on rail and road
- Transport modes and supply patterns
- Time tables

**Spatial Development and Infrastructure Systems Master - Key for Type**

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

| V  | lecture           | P  | practical/laboratory course |
| G  | lecture with exercise | A  | independent project |
| U  | exercise          | D  | diploma thesis |
| S  | seminar           | R  | revision course / private study |
| K  | colloquium        |    |                          |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## First Year Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0151-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5 credits</td>
<td>3V+2U</td>
<td>V. C. Gradinaru</td>
</tr>
<tr>
<td>Abstract</td>
<td>Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decompostion, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, S. Auflage 2002</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taught competencies</td>
<td>Concepts and Theories assessed</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Techniques and Technologies assessed</td>
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<tr>
<td></td>
<td>Analytical Competencies assessed</td>
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<tr>
<td></td>
<td>Decision-making assessed</td>
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<tr>
<td></td>
<td>Problem-solving assessed</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Communication not assessed</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork not assessed</td>
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<tr>
<td></td>
<td>Creative Thinking assessed</td>
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<tr>
<td></td>
<td>Critical Thinking assessed</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Discrete Mathematics</th>
<th>O</th>
<th>7 credits</th>
<th>4V+2U</th>
<th>U. Maurer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Content: Mathematical reasoning and proofs, abstraction, Sets, relations (e.g. equivalence and order relations), functions, (un-)countability, number theory, algebra (groups, rings, fields, polynomials, subalgebras, morphisms), logic (propositional and predicate logic, proof calculi).</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The primary goals of this course are (1) to introduce the most important concepts of discrete mathematics, (2) to understand and appreciate the role of abstraction and mathematical proofs, and (3) to discuss a number of applications, e.g., in cryptography, coding theory, and algorithm theory.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>See course description.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>available (in english)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Computer Science</th>
<th>O</th>
<th>6 credits</th>
<th>2V+2U+1P</th>
<th>F. O. Friedrich Wicker, R. Sasse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0231-10L</td>
<td>Analysis I</td>
<td>O</td>
<td>8 credits</td>
<td>4V+3U</td>
<td>T. Rivière</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students in BSc EEIT may instead register for 401-1261-07L/401-1262-07L Analysis I: One Variable/Analysis II: Several Variables instead of 401-0231-10L/401-0232-10L Analysis I/Analysis 2 must get in touch with the Study Administration before the registration.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Reelle und komplexe Zahlen, Grenzwerte, Folgen, Reihen, Potenzreihen, stetige Abbildungen, Differential- und Integralrechnung einer Variablen, Einführung in gewöhnliche Differentialgleichungen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Christian Blatter: Ingenieur-Analyse (Kapitel 1-4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Konrad Koenigsberger, Analysis I. Christian Blatter, Analysis I.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Physics I</th>
<th>O</th>
<th>4 credits</th>
<th>3V+1U</th>
<th>S. P. Quanz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids) Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>The lecture follows the book &quot;Physics&quot; by Paul A. Tipler.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Basic Courses
Block G1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0353-00L</td>
<td>Analysis 3</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>M. Iacobelli</td>
</tr>
</tbody>
</table>

**Abstract**
In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

**Objective**
The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

**Content**

1. General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)

2. Quasilinear first order PDEs
   - Solution with the method of characteristics
   - Conservation laws

3. Hyperbolic PDEs
   - wave equation
   - d'Alembert formula in (1+1)-dimensions
   - method of separation of variables

4. Parabolic PDEs
   - heat equation
   - maximum principle
   - method of separation of variables

5. Elliptic PDEs
   - Laplace equation
   - maximum principle
   - method of separation of variables
   - variational method

**Literature**

**Prerequisites / notice**
Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0647-00L</td>
<td>Introduction to Mathematical Optimization</td>
<td>O</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>D. Adjiashvili</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

**Objective**
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

**Content**

- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

**Literature**
Information about relevant literature will be given in the lecture.

**Prerequisites / notice**
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2673-00L</td>
<td>Numerical Methods for CSE</td>
<td>O</td>
<td>9 credits</td>
<td>2V+2U+4P</td>
<td>R. Hiptmair</td>
</tr>
</tbody>
</table>

**Abstract**
The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

**Objective**
- Knowledge of the fundamental algorithms in numerical mathematics
- Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
- Ability to choose the appropriate numerical method for concrete problems
- Ability to interpret numerical results
- Ability to implement numerical algorithms efficiently

**Content**
- Computing with Matrices and Vectors
- Direct Methods for linear systems of equations
- Least Squares Techniques
- Data Interpolation and Fitting
- Iterative Methods for non-linear systems of equations
- Filtering Algorithms
- Approximation of Functions
- Numerical Quadrature

**Literature**
M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002
P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

**Prerequisites / notice**
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Knowledge of C++ is taken for granted.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

#### Block G2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>O</td>
<td>5 credits</td>
<td>4G</td>
<td>R. Käppeli</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>This course does not cover how to design or build a processor or computer.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Lecture notes | - C programming
- Integers
- Pointers and dynamic memory allocation
- Basic computer architecture
- Compiling C control flow and data structures
- Code vulnerabilities
- Implementing memory allocation
- Linking
- Floating point
- Optimizing compilers
- Architecture and optimization
- Caches
- Exceptions
- Virtual memory
- Multicore
- Devices |
| Literature    | The course is based in part on "Computer Systems: A Programmer's Perspective" (3rd Edition) by R. Bryant and D. O'Hallaron, with additional material. |
| Prerequisites / notice | 252-0029-00L Parallel Programming
252-0028-00L Design of Digital Circuits |

### Block G3

All course units within Block G3 are offered in the spring semester.

### Block G4

All course units within Block G4 are offered in the spring semester.
### Core Courses from Group I (Modules)

#### Module A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0107-20L</td>
<td>High Performance Computing for Science and Engineering (HPCSE) I</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

**Content**

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

**Lecture notes**

https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/  
Class notes, handouts

**Literature**

- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann  
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press  
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann  
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press  
- Lecture notes

**Prerequisites / notice**

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

#### Module B

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>W</td>
<td>9 credits</td>
<td>3V+2U+3A</td>
<td>T. Hoefler, M. Püschel</td>
</tr>
</tbody>
</table>

**Number of participants limited to 125.**

**Abstract**

Advanced topics in parallel and high-performance computing.

**Objective**

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

**Content**

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice**

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

#### Module C

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0107-20L</td>
<td>High Performance Computing for Science and Engineering (HPCSE) I</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

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4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/

Class notes, handouts

Literature
• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
• Lecture notes

Prerequisites / notice
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

► Core Courses from Group II
No offering in the Autumn Semester.

► Fields of Specialization

► Astrophysics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-7851-00L</td>
<td>Theoretical Astrophysics (University of Zurich)</td>
<td>W</td>
<td>10 credits</td>
<td>4V+2U</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Abstract
This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content
This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

Literature
Course Materials:
1. The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
2. The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
3. Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
4. Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
5. Galactic Dynamics, James Binney and Scott Tremaine

Prerequisites / notice
This is a full blackboard ad chalk experience for students with a strong background in mathematics and physics.

Prior Knowledge:
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics

401-7855-00L | Computational Astrophysics (University of Zurich) | W | 6 credits | 2V | L. M. Mayer |

Objective
Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes
### Physics of the Atmosphere

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0023-00L</td>
<td>Atmosphere</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>E. Fischer, T. Peter</td>
</tr>
</tbody>
</table>

**Abstract**
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

**Objective**
Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

**Content**
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

**Lecture notes**
Written information will be supplied.

**Literature**

### Chemistry

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0004-01L</td>
<td>Classical Simulation of (Bio)Molecular Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>P. H. Hünenberger, J. Dolenc, S. Riniker</td>
</tr>
</tbody>
</table>

**Abstract**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Objective**
Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

**Content**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Lecture notes**
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

**Literature**
See: www.csms.ethz.ch/education/CSBMS

**Prerequisites / notice**
Possible bonus of up to 0.25 points on the exam mark.

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

### Fluid Dynamics

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0103-00L</td>
<td>Fluid Dynamics II</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>P. Jenny</td>
</tr>
</tbody>
</table>

**Abstract**
Two-dimensional irrotational (potential) flows: stream function and potential, singularity method, unsteady flow, aerodynamic concepts.
Vorticity dynamics: vorticity and circulation, vorticity equation, vortex theorems of Helmholtz and Kelvin.
Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Mayer expansion, viscous effects.

**Objective**
Expand basic knowledge of fluid dynamics.

**Content**
Two-dimensional irrotational (potential) flows: stream function and potential, complex notation, singularity method, unsteady flow, aerodynamic concepts.
Vorticity dynamics: vorticity and circulation, vorticity equation, vortex theorems of Helmholtz and Kelvin.
Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Mayer expansion, viscous effects.

**Lecture notes**
Lecture notes are available (in German).
(See also info on literature below.)

**Literature**
Related chapters (corresponding to lecture notes) from the textbook

**Prerequisites / notice**
Analysis III, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas

### Systems and Control

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
</tbody>
</table>

**Abstract**
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.
<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Signals and Systems Theory II.</td>
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**Robotics**

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0045-00L</td>
<td>Signals and Systems I</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>to be announced</td>
</tr>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>E. Konukoglu, F. Yu</td>
</tr>
</tbody>
</table>

**Advanced Machine Learning**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0535-00L</td>
<td>Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1933 of 2345
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes: No lecture notes, but slides will be made available on the course webpage.

**Literature**

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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**263-3210-00L Deep Learning**
Number of participants limited to 320.

**Abstract**
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

**Prerequisites / notice**
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/

  Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning
  https://ias.inf.ethz.ch/teaching/introml-S19

  Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/

  Computational Statistics
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence
  https://ias.inf.ethz.ch/teaching/pai-f18

**151-0563-01L Dynamic Programming and Optimal Control**

**Abstract**
Introduction to Dynamic Programming and Optimal Control.

**Objective**
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

**Literature**

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

**151-0851-00L Robot Dynamics**

**Abstract**
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.
Objective

The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content

The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Prerequisites / notice

The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

Materials

- Table

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
</tr>
<tr>
<td>263-5210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
</tr>
<tr>
<td>402-0809-00L</td>
<td>Introduction to Computational Physics</td>
<td>W</td>
<td>8 credits</td>
<td>2V+2U</td>
<td>A. Adelmann</td>
</tr>
<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4 credits</td>
<td>3V+2U</td>
<td>M. Schweizer</td>
</tr>
</tbody>
</table>

For the category assignment take contact with the Study Administration (www.math.ethz.ch/studiensekretariat).
Objective

This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Content

Topics to be covered include

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Lecture notes

Lecture notes will be sold at the beginning of the course.

Literature

Lecture notes will be sold at the beginning of the course. Additional (background) references are given there.

Prerequisites / notice

Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

401-4657-00L Numerical Solution of Stochastic Ordinary Differential Equations W 6 credits 3V+1U A. Stein

Abstract

This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective

The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content

Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes

There will be English, typed lecture notes for registered participants in the course.

Literature


Prerequisites / notice

Prerequisites: Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.

a) mandatory courses:
Elementary Probability, Probability Theory I.

b) recommended courses:
Stochastic Processes.

Start of lectures: Wednesday September 21, 2022.

Electromagnetics

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.
Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

★★★ Geophysics

Recommended combinations:
- Subject 1 + Subject 2
- Subject 1 + Subject 3
- Subject 2 + Subject 3
- Subject 3 + Subject 4
- Subject 5 + Subject 6 + Subject 8
- Subject 4 + Subject 5
- Subject 7 + Subject 8

★★★ Geophysics: Subject 1

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<tr>
<td>651-4007-00L</td>
<td>Continuum Mechanics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>T. Gerya</td>
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Abstract
In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth's mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications.

Objective
The goal of this course is to learn and understand few principal partial differential equations (conservation laws) that are applicable for analyzing and modelling of any continuum including the Earth's mantle, core, atmosphere and ocean. By the end of the course, students should be able to write, explain and analyse the equations and apply them for simple analytical cases. Numerical solving of these equations will be discussed in the Numerical Modelling I and II course running in parallel.

Content
A provisional week-by-week schedule (subject to change) is as follows:

Weeks 1,2: The continuity equation
Exercises: Computing the divergence of velocity field.

Weeks 3,4: Density and gravity
Exercises: Computing density, thermal expansion and compressibility from an equation of state. Derivation of gravitational acceleration and its divergence from gravitational potential.

Weeks 5,6: Stress and strain
Exercises: Analysing strain rate tensor for solid body rotation. Computing stress invariants

Weeks 7,8: The momentum equation

Week 9: Viscous rheology of rocks
Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth's interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws.
Exercises: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Weeks 10,11: The heat conservation equation
Exercises: Computing heat fluxes. Deriving equation for steady state temperature profile in a magmatic channel.

Week 12,13: Elasticity and plasticity


Lecture notes
GRADING will be based on homeworks (1/3) and oral exam (2/3).

Literature
Script and Exam questions are available by request tgerya@ethz.ch

★★★ Geophysics: Subject 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4241-00L</td>
<td>Numerical Modelling I and II: Theory and Applications</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>T. Gerya</td>
</tr>
</tbody>
</table>
Abstract
In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasise a hands-on learning approach rather than extensive theory.

Objective
The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

Content
A provisional week-by-week schedule (subject to change) is as follows:

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.</td>
</tr>
<tr>
<td>2</td>
<td>Direct and iterative methods for obtaining numerical solutions. Solving of 2D Poisson equation with direct method. Solving of 2D Poisson equation with Gauss-Seidel and Jacobi iterative methods.</td>
</tr>
<tr>
<td>3</td>
<td>Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.</td>
</tr>
<tr>
<td>4</td>
<td>Staggered grid for formulating momentum and continuity equations. Indexing of unknowns. Solving momentum and continuity equations in case of constant viscosity using pressure-velocity formulation with staggered grid.</td>
</tr>
<tr>
<td>5</td>
<td>Conservative finite differences for the momentum equation. &quot;Free slip&quot; and &quot;no slip&quot; boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.</td>
</tr>
<tr>
<td>7</td>
<td>Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.</td>
</tr>
<tr>
<td>9</td>
<td>Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.</td>
</tr>
<tr>
<td>10</td>
<td>Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.</td>
</tr>
<tr>
<td>11</td>
<td>Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.</td>
</tr>
<tr>
<td>12</td>
<td>Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.</td>
</tr>
</tbody>
</table>

GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature

Geophysics: Subject 3
Offered in the spring semester

Geophysics: Subject 4
Offered in the spring semester

Geophysics: Subject 5
Offered in the spring semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4014-00L</td>
<td>Seismic Waves II</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>T. Diehl, F. Lanza, A. Obermann</td>
</tr>
</tbody>
</table>

Abstract
This course provides an overview of the most widely used seismological methods to image the Earth's interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Objective
Understand the strengths and weaknesses of various active and passive tomographic methods to image the structure of the Earth.


Geophysics: Subject 6
Offered in the spring semester

Geophysics: Subject 7
Offered in the spring semester
Bioinformatics: Subject 8

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>6</td>
<td>V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper</td>
</tr>
</tbody>
</table>

Geophysics: Subject 8

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4273-00L</td>
<td>Numerical Modelling in Fortran</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Tackley</td>
</tr>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td>636-0706-00L</td>
<td>Spatio-Temporal Modelling in Biology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Iber</td>
</tr>
</tbody>
</table>

Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4273-00L</td>
<td>Numerical Modelling in Fortran</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Tackley</td>
</tr>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td>636-0706-00L</td>
<td>Spatio-Temporal Modelling in Biology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Iber</td>
</tr>
</tbody>
</table>

Both courses provide an introduction to the fundamental concepts and computational methods for the analysis of complex biological networks. The courses cover a range of topics, from systems biology to bioinformatics, and are suitable for students with minimal programming experience. The focus is on Fortran, a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:

- G. Indiveri, D. Kiper, Mathematical Biology, Springer
- M. Cook, B. Grewe, G. Indiveri, D. Kiper,
Abstract
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enforcements and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, the neural architectures of feedforward and recurrent networks will be discussed in the context of co-ordination, control, and integration of sensory and motor information in neural networks.

Electives
In the 'electives' subcategory, at least two course units must be successfully completed.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0709-00L</td>
<td>Stochastic Methods for Engineers and Natural Scientists</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>D. W. Meyer-Massetti</td>
</tr>
</tbody>
</table>

Abstract
The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent and subsurface flows. Moreover, mathematical techniques are presented that are used to quantify uncertainty in various engineering applications.

Objective
By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover, you should be able to develop basic stochastic models of such systems.

Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Itô calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
All topics are illustrated with engineering applications.

Literature
Some textbooks related to the material covered in the course:

Taught competencies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taught competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Method-specific Competencies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Taught competencies</td>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Personal Competencies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Creative Thinking</th>
<th>assessed</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Taught competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
<td></td>
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</tr>
</tbody>
</table>

151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality: basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

Lecture notes
The handout is available in German and English.

Prerequisites / notice
“Visualization, Simulation and Interaction - Virtual Reality I” is recommended, but not mandatory.

Didactical concept:
The course consists of lectures and exercises.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### 151-0833-00L Applied Finite Element Analysis

**W 4 credits 2V+2U B. Berisha, D. Mohr**

**Abstract**

Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

**Objective**

The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

**Content**

- introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

**Lecture notes**

Lecture slides

**Literature**


### 151-0529-00L Computational Mechanics II: Nonlinear FEA

**W 4 credits 2V+2U L. De Lorenzis**

**Abstract**

The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

**Objective**

To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

**Content**

1. Introduction: various sources of nonlinearities and implications for FEA.
4. Non-linear boundary conditions; contact problems.

**Prerequisites / notice**

Lecture notes will be provided. However, students are encouraged to take their own notes.

**Literature**

Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

### 263-2800-00L Design of Parallel and High-Performance Computing

**W 9 credits 3V+2U+3A T. Hoefler, M. Püschel**

**Abstract**

Advanced topics in parallel and high-performance computing.

**Objective**

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

**Content**

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice**

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

### 227-0102-00L Discrete Event Systems

**W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer**

**Abstract**

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Textbook and all further documents in English.

References
Prerequisites: Basics of digital circuits.

Examination: In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details: https://bsi-students.ee.ethz.ch/lectures/vlsi-i/

Electives (CSE Master)

see also Fields of Specialization

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0147-10L</td>
<td>VLSI 3: Full-Custom Digital Circuit Design</td>
<td>W</td>
<td>6</td>
<td></td>
<td>After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.</td>
<td>The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include: Nanometer MOSFETs, Static and dynamic behavior of complementary MOS (CMOS) inverters, CMOS gate design, sizing, and timing, Full-custom standard-cell design, Wire models and parasitics, Latch and flip-flop circuits, Gate-level timing analysis and optimization, Static and dynamic power consumption, low-power techniques, Alternative logic styles (dynamic logic, pass-transistor logic, etc.), Arithmetic and logic circuits, Fixed-point and floating-point arithmetic, Synchronous and asynchronous design principles, Memory circuits (ROM, SRAM, and DRAM), In- and near-memory processing architectures, Full-custom accelerator circuits for machine learning, The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.</td>
</tr>
<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W</td>
<td>6</td>
<td></td>
<td></td>
<td>The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity.</td>
</tr>
<tr>
<td>227-0971-00L</td>
<td>Computational Psychiatry</td>
<td>W</td>
<td>3</td>
<td></td>
<td></td>
<td>This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.</td>
</tr>
<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10</td>
<td></td>
<td></td>
<td>Las Vegas &amp; Monte Carlo algorithms: inequalities of Markov, Chebyshev, Chernoff; negative correlation: Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.</td>
</tr>
</tbody>
</table>

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and

Abstract

This course provides an introduction to the core concepts of computer graphics, image processing, multimedia and computer vision. The course forms a basis for the specialization track Visual Computing of the CS master program at ETH.

Objective

This course provides an in-depth introduction to the core concepts of computer graphics, image processing, multimedia and computer vision. The course forms a basis for the specialization track Visual Computing of the CS master program at ETH.

Content

Course topics will include: Graphics pipeline, perception and color models, camera models, transformations and projection, projections, lighting, shading, global illumination, texturing, sampling theorem, Fourier transforms, image representations, convolution, linear filtering, diffusion, nonlinear filtering, edge detection, optical flow, image and video compression.

In theoretical and practical homework assignments students will learn to apply and implement the presented concepts and algorithms.

Lecture notes

A scriptum will be handed out for a part of the course. Copies of the slides will be available for download. We will also provide a detailed list of references and textbooks.

Literature


252-0543-01L

Computer Graphics

This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

Abstract

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

Objective

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

Content

This course covers some of the fundamental concepts of computer graphics. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

Literature

Books:

High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting

Multiple view geometry in computer vision

Physically Based Rendering: From Theory to Implementation

Prerequisites / notice

Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.

The programming assignments will be in C++. This will not be taught in the class.

252-0546-00L

Physically-Based Simulation in Computer Graphics

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Abstract

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective

The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Content

The programming assignments will be in C++. This will not be taught in the class.

Prerequisites / notice

Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

252-0834-00L

Information Systems for Engineers

This course provides the basics of relational databases from the perspective of the user.

Abstract

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective
This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content
Using a relational database
1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level
6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database
12. Data cubes

Outlook
13. Outlook

Literature
- Lecture material (slides).
It is not required to buy the book, as the library has it

Prerequisites / notice
For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
Objective
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

Literature
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice
Basic knowledge in probability and statistics

401-3901-00L
Linear & Combinatorial Optimization
Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature

Prerequisites / notice
Solid background in linear algebra.
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinae and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, conductance amplifier, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

**Additional Electives from the Fields of Specialization (CSE Master)**

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<th>Number</th>
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<td>651-4053-05L</td>
<td>Boundary Layer Meteorology</td>
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<td>M. Rotach, P. Calanca</td>
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<td>Boundary Layer Meteorology”, (Kluwer),</td>
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<td>- Panofsky, H. A. and Dutton, J.A.: 1984,</td>
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<td>- Kaimal JC and Finningan JJ: 1994,</td>
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<td>Atmospheric Boundary Layer Flows,</td>
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<td>- Wyngaard JC: 2010, Turbulence in the</td>
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<td>Atmosphere, Cambridge University Press,</td>
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Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1947 of 2345
1) Introductory lecture: basics of quantum mechanics and quantum chemistry

2) Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles

3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom

4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians

5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian

6) Relativistic effects in chemistry and the emergence of spin

7) Spin in density functional theory

8) New-electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group

9) Quantum chemistry without the Born-Oppenheimer approximation


2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997 [english version available: F. Schwabl, Advanced Quantum Mechanics]

3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992


8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group

9) Quantum chemistry without the Born-Oppenheimer approximation

Note also the standard textbooks:

A) Szabo, N.S. Ostlund. Quantum chemistry, Dover Publications

B) I. N. Levine, Quantum Chemistry, Pearson


Objective
Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.

Content
The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:
1. Background: Elements of statistical mechanics and kinetic theory:
   - Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   - Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.
2. Basics of the Lattice Boltzmann Method and Simulations:
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.
3. Hands on:
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).
4. Practical issues of LBM for fluid dynamics simulations:
   - Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.
5. Microflow:
   - Rarefraction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.
6. Advanced lattice Boltzmann methods:
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objectives
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

636-0017-00L Computational Biology  W 6 credits  3G+2A  T. Vaughan, C. Magnus, T. Stadler

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

### Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3667-72L</td>
<td>Case Studies Seminar (Autumn Semester 2022)</td>
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<td>V. Gradinaru, R. Hiptmair</td>
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</table>

**Abstract**
Invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list. Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

In the CSE Case Studies Seminar invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list (containing articles from, e.g., Nature, Science, Scientific American, etc.). If the underlying paper comprises more than 15 pages, two or three consecutive case studies presentations delivered by different students can be based on it. Consistency in layout, style, and contents of those presentations is expected.

Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

**Prerequisites / notice**
The talks might be given via Zoom; talks in presence should be also streamed in Zoom.

75% attendance and a short presentation on a published paper out of a list or on some own project are mandatory.

Students have to register their presentations online until the second Wednesday of the semester on https://rw.ethz.ch/the-programme/case-studies.html

The student talks will be grouped by subject, so we’ll decide the actual dates of the individual talks.

Students that realize that they will not fulfill this criteria have to contact the teaching staff or de-register before the end of semester from the Seminar if they want to avoid a “Fail” in their documents. Late de-registrations will not be considered.

### Taught competencies

**Subject-specific Competencies**
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Method-specific Competencies**
- Communication
- Cooperation and Teamwork

**Social Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Science in Perspective

#### Science in Perspective

- [see Science in Perspective: Type A: Enhancement of Reflection Capability](#)

- [Recommended Science in Perspective (Type B) for D-MATH](#)

#### Science in Perspective

- [see Science in Perspective: Language Courses ETH/UZH](#)

### Bachelor’s Thesis

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.

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**Target audience:** Third year Bachelor students; Master students who cannot document to have received an adequate training in working scientifically.

**Abstract**
Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)

**Objective**
Learn the basic standards of scientific works in mathematics.

**Content**
- Types of mathematical works
- Publication standards in pure and applied mathematics
- Data handling
- Ethical issues
- Citation guidelines

**Prerequisites / notice**
Lunch Sessions – Thesis Basics for Mathematics

**Students**
Details and registration for the optional MathBib training course: [https://www.math.ethz.ch/mathbib-schulungen](https://www.math.ethz.ch/mathbib-schulungen)

**Abstract**
Optional MathBib training course

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Scientific Works in Physics

**W** 0 credits

**Target audience:**
Master students who cannot document to have received an adequate training in working scientifically.

**Directive**

**Abstract**
Literature Review: ETH-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX; Mathematical Writing, AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.

**Objective**
Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.

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Bachelor’s Thesis

**O** 14 credits 30D

**Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics or 402-2000-00L Scientific Works in Physics is required.**

**Abstract**
The BSc thesis concludes the curriculum. In their BSc thesis, students should demonstrate their ability to carry out independent, structured scientific work. The purpose of the BSc thesis is to deepen knowledge in a certain subject and to bring students into closer contact with applications in an existing computational group. The BSc thesis requires approximately 420 hours of work.

**Objective**
In their BSc thesis, students should demonstrate their ability to carry out independent, structured scientific work. The purpose is to deepen knowledge in a certain subject and to enable students to collaborate in an existing scientific group to take a computational approach to problems encountered in applications.

**Prerequisites / notice**
The supervisor responsible for the Bachelor thesis defines the task and determines the start and the submission date. The Bachelor thesis concludes with a written report. The Bachelor thesis is graded.

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Zurich Colloquium in Applied and Computational Mathematics

**E-** 0 credits

**Abstract**
Research colloquium

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**Colloquia**

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**Computational Science and Engineering Bachelor - Key for Type**

- **O** Compulsory
- **W+** Eligible for credits and recommended
- **W** Eligible for credits
- **Z** Courses outside the curriculum
- **Dr** Suitable for doctorate
- **E-** Recommended, not eligible for credits
- **P** practical/laboratory course
- **A** independent project
- **D** diploma thesis
- **R** revision course / private study

**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Computational Science and Engineering Master

Core Courses

In the ‘core courses’ subcategory, at least two course units must be successfully completed.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>J. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Model Selection Techniques
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Core Courses (continued)

Only one of the two course units 252-0535-00L Advanced Machine Learning resp. 263-5210-00L Probabilistic Artificial Intelligence may be recognised for credits. More precisely, it is also not allowed to have recognised one course unit for the Bachelor's and the other course unit for the Master's degree.

For the category assignment take contact with the Study Administration (www.math.ethz.ch/studiensekretariat).

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<tr>
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<tbody>
<tr>
<td>263-5210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
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</tbody>
</table>

Abstract

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content

Topics covered:

- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayes tree learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Fields of Specialization

Astrophysics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-7851-00L</td>
<td>Theoretical Astrophysics (University of Zurich)</td>
<td>W</td>
<td>10 credits</td>
<td>4V+2U</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>
**Course Materials:**

Lecturers: Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

- M. Rotach
- L. M. Mayer

**ECTS:**

Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts.

This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

**Autumn Semester 2022**

4 credits

**Abstract**

This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

**Content**

This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

**Prerequisites / notice**

This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

- Mathematical Methods for the Physicist
- Quantum Mechanics (All preferred but not obligatory)
- Mechanics
- Quantum Mechanics and atomic physics
- Thermodynamics
- Fluid Dynamics
- Electrodyamics

**Computational Astrophysics (University of Zurich)**

401-7855-00L

- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- UZH Module Code: AST245
- M. Rotach

**ECTS:**

6 credits

2V

L. M. Mayer

**Objective**

Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes.

**Content**

1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics; Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

**Literature**

- Galactic Dynamics (Binney & Tremaine, Princeton University Press),
- Computer Simulation using Particles (Hockney & Eastwood CRC press),
- Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

**Prerequisites / notice**

Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

**Physics of the Atmosphere**

**Number**

701-0023-00L

**Title**

Atmosphere

**Type**

W

**ECTS**

3 credits

2V

**Lecturers**

- E. Fischer
- T. Peter

**Abstract**

Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

**Objective**

Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

**Content**

Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

**Lecture notes**

Written information will be supplied.

**Literature**


**Number**

651-4053-05L

**Title**

Boundary Layer Meteorology

**Type**

W

**ECTS**

4 credits

3G

**Lecturers**

- M. Rotach
- P. Calanca

**Abstract**

The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

**Objective**

Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts.

Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).
In this seminar, the process of writing a scientific proposal is introduced and the essential elements, including the peer review process, are outlined and class exercises train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work. An introduction to presentation skills is provided.

Objective
- Scientific writing
- Introduction to peer review process
- Correction / feedback to the proposals of other participants
- Presentation skills

Content
This seminar is mandatory to write a proposal about an upcoming MSc thesis or semester project. If no such project is planned, this proposal and evaluation of each other's work. Furthermore, an introduction to presentation skills is provided.

Prerequisites / notice
Seminar cannot be taken. Please contact the lecturers (hanna.joos@env.ethz.ch) on time if you plan to take this seminar.
Objective

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

Content

1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group
9) Quantum chemistry without the Born-Oppenheimer approximation

Lecture notes

A set of detailed lecture notes will be provided, which will cover the whole course.

Literature

2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992

Note also the standard textbooks:

A) Szabo, N.S. Ostlund, Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Prerequisites / notice

Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

401-5940-00L Seminar In Chemistry for CSE W 4 credits 2S P. H. Hünenberger, M. Reiher

Abstract

The student will carry out a literature study on a topic of his or her liking (suggested by or in agreement with the supervisor) in the area of computer simulation in chemistry (Prof. Hünenberger) or of quantum chemistry (Prof. Reiher), the results of which are to be presented both orally and in written form.

For more information:

http://www.csms.ethz.ch/education/CSE_seminar.html

Fluid Dynamics

One of the course units

151-0103-00L Fluid Dynamics II 151-0109-00L Turbulent Flows

is compulsory.

Students able to follow courses in German are advised to choose 151-0103-00L Fluid Dynamics II.

Number Title Type ECTS Hours Lecturers

151-0103-00L Fluid Dynamics II O 3 credits 2V+1U P. Jenny

Abstract


Objective

Explain basic knowledge of fluid dynamics.

Content


Lecture notes

Lecture notes are available (in German). (See also info on literature below.)

Literature

Relevant chapters (corresponding to lecture notes) from the textbook


Prerequisites / notice

Analysis III, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas

151-0109-00L Turbulent Flows W 4 credits 2V+1U P. Jenny
Abstract
- Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scallings. Homogeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows

Objective
Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling

Content
- Properties of laminar, transitional and turbulent flows.
- Origin and control of turbulence. Instability and transition.
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.
- Scallings, homogeneous isotropic turbulence, energy spectrum.
- Turbulent free shear flows. Jet, wake, mixing layer.
- Wall-bounded turbulent flows.
- Turbulent flow computation and modeling.

Lecture notes
Lecture notes are available

Literature

151-0532-00L Nonlinear Dynamics and Chaos I W 4 credits 2V+2U G. Haller
Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

151-0213-00L Fluid Dynamics with the Lattice Boltzmann Method W 4 credits 3G I. Karlin
Abstract
The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Objective
Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
The course builds upon three parts:
I. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II. Theoretical basis of statistical mechanics and kinetic equations.
III. Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   - Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory; Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   - Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   - Lattice Boltzmann simulations of turbulent flows;
   - Numerical stability and accuracy.

5. Microflow:
   - Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB methods beyond hydrodynamics:
   - Relativistic fluid dynamics; flows with phase transitions.

Lecture notes:
Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice:
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>credits</td>
<td>6</td>
</tr>
<tr>
<td>Abstract</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
<td></td>
<td></td>
<td></td>
<td>F. Dörfler</td>
</tr>
<tr>
<td>Objective</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Signal and Systems Theory II.</td>
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<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6</td>
<td>credits</td>
<td>5</td>
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<tr>
<td>Abstract</td>
<td>The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems. Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems. - Proof techniques and practices. - Linear spaces, normed linear spaces and Hilbert spaces. - Ordinary differential equations, existence and uniqueness of solutions. - Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case. - Controllability and observability, duality. Time invariant systems treated as a special case. - Stability and stabilization, observers, state and output feedback, separation principle.</td>
<td></td>
<td></td>
<td></td>
<td>J. Lygeros, A. Tsiamis</td>
</tr>
<tr>
<td>Objective</td>
<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.</td>
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<tr>
<td>Content</td>
<td>Available on the course Moodle platform.</td>
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<tr>
<td>Lecture notes</td>
<td>Available on the course Moodle platform.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Sufficient mathematical maturity, in particular in linear algebra, analysis.</td>
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</tbody>
</table>
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

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Seminar in Systems and Control for CSE

J. M. Buhmann

Course material: Script, computer demonstrations, exercises and problem solutions


Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the

3V+1U

Image Analysis and Computer Vision

Lecturers

Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition

(intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics,

and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple
degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations,

forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation,
sensing, vision, and control.

Theory of Robotics and Mechatronics


The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

401-5850-00L Seminar in Systems and Control for CSE W 4 credits 2S J. Lygeros

Robotics

Only one of the two course units

263-5902-00L Computer Vision resp.

227-0447-00L Image Analysis and Computer Vision

may be recognised for credits. More precisely, it is also not allowed to have recognised one course unit for the Bachelor's and the other course unit for

the Master's degree.

Number Title Type ECTS Hours Lecturers

151-0601-00L Theory of Robotics and Mechatronics W 4 credits 3G to be announced

Abstract This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations,

forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation,
sensing, vision, and control.

Objective Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition

(intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics,

and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple
degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Content An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations,

forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation,
sensing, vision, and control.

Lecture notes available.

227-0447-00L Image Analysis and Computer Vision W 6 credits 3V+1U E. Konukoglu, F. Yu


Image segmentation. Motion extraction and tracking. 3D data extraction. Invariant features. Specific object recognition and object class


Objective Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience

through practical computer and programming exercises.

Content This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep

learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image

processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is

considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then

turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic

information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific

objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based

approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets

are given.

Lecture notes Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the

classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data

analysis. This course is accompanied by practical machine learning projects.

Objective Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics

knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms

and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine

learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Literature**

**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
Objective
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state-of-the-art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content
The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Prerequisites / notice
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

401-5860-00L Seminar in Robotics for CSE

Abstract
This course provides an opportunity to familiarize yourself with the advanced topics of robotics and mechatronics research. The study plan has to be discussed with the lecturer based on your specific interests and/or the relevant seminar series such as the IRIS's Robotics Seminars and BIRONZ lectures, for example.

Objective
The students are familiar with the challenges of the fascinating and interdisciplinary field of Robotics and Mechatronics. They are introduced in the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Content
This 4 ECTS course requires each student to discuss a study plan with the lecturer and select minimum 10 relevant scientific publications to read through, or attend 5-10 lectures of the public robotics oriented seminars (e.g. Public robotics seminars such as the IRIS's Robotics Seminars http://www.iris.ethz.ch/iris/series/, and BIRONZ lectures http://www.birl.ethz.ch/bironz/index are good examples). At the end of the semester, the results should be presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

★★ Robotics (continued)

Only one of the two course units
263-5902-00L Computer Vision resp. 227-0447-00L Image Analysis and Computer Vision may be recognised for credits. More precisely, it is also not allowed to have recognised one course unit for the Bachelor's and the other course unit for the Master's degree.

The same restriction applied to the two course units
263-5210-00L Probabilistic Artificial Intelligence resp. 252-0535-00L Advanced Machine Learning.

For the category assignment take contact with the Study Administration (www.math.ethz.ch/studiensekretariat).

Number Title Type ECTS Hours Lecturers
263-5902-00L Computer Vision W 8 credits 3V+1U+3A M. Pollefeys, S. Tang, F. Yu

Abstract
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition.

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

263-5210-00L Probabilistic Artificial Intelligence

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.

★★ Physics

For the field of specialization 'Physics' basic knowledge in quantum mechanics is required.

Number Title Type ECTS Hours Lecturers
402-0809-00L Introduction to Computational Physics W 8 credits 2V+2U A. Adelmann

Abstract
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

Objective
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Content
Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some introductory applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1961 of 2345
This is the first of two courses, introducing particle accelerators from a theoretical point of view and covers state-of-the-art modelling techniques.

Objective
You understand the building blocks of particle accelerators. Modern analysis tools allows you to model state-of-the-art particle accelerators. In some of the exercises you will be confronted with next generation machines. We will develop a Python (or Julia) simulation tool (pyAcceLEGOrator or jAcceLEGOrator) that reflects the theory from the lecture.

Content
Here is the rough plan of the topics, however the actual pace may vary relative to this plan.

- Recap of Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

Lecture notes
Lecture notes

Prerequisites / notice
Physics, Computational Science (RW) at BSc. Level

This lecture is also suited for PhD. students.
Seminar in Physics for CSE

W 4 credits 2S A. Adelmann

Abstract
In this seminar, the students present a talk on an advanced topic in modern theoretical or computational physics. An implementation of an advanced algorithm can also be presented.

Objective
To teach students the topics of current interest in computational and theoretical physics.

Computational Finance

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4 credits</td>
<td>3V+2U</td>
<td>M. Schweizer</td>
</tr>
</tbody>
</table>

Abstract
First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Content
- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô’s formula, Girsanov transformation, Itô’s representation theorem
- Black–Scholes formula

Lecture notes
Lecture notes will be sold at the beginning of the course.

Literature
Lecture notes will be sold at the beginning of the course. Additional (background) references are given there.

Prerequisites / notice
Prerequisites: Results and facts from probability theory as in the book “Probability Essentials” by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course “Wahrscheinlichkeitstheorie”.)

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

Numerical Solution of Stochastic Ordinary Differential Equations

W 6 credits 3V+1U A. Stein

Abstract
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content
Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes
There will be English, typed lecture notes for registered participants in the course.

Literature


Prerequisites / notice
Prerequisites:
Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.

a) mandatory courses:
Elementary Probability,
Probability Theory I.

b) recommended courses:
Stochastic Processes.

Start of lectures: Wednesday September 21, 2022.

Financial Engineering (University of Zurich)

W 6 credits 4G

Does not take place this semester.

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: MFOEC200
Mind the enrolment deadlines at UZH:

Abstract
This lecture is intended for students who would like to learn more on equity derivatives modelling and pricing.

Objective
Quantitative models for European option pricing (including stochastic volatility and jump models), volatility and variance derivatives,
American and exotic options.

Content
After introducing fundamental concepts of mathematical finance including no-arbitrage, portfolio replication and risk-neutral measure, we will present the main models that can be used for pricing and hedging European options e.g. Black-Scholes model, stochastic and jump-diffusion models, and highlight their assumptions and limitations. We will cover several types of derivatives such as European and American options, Barrier options and Variance Swaps. Basic knowledge in probability theory and stochastic calculus is required. Besides attending class, we strongly encourage students to stay informed on financial matters, especially by reading daily financial newspapers such as the Financial Times or the Wall Street Journal.

Lecture notes
Script.

Prerequisites / notice
Basic knowledge of probability theory and stochastic calculus.
Asset Pricing.

363-0561-00L
Financial Market Risks
Does not take place this semester.

Abstract
I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

Objective
The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

-Development of the concepts and tools to understand these risks and master them.

-Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)

-Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks
1- The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of the perpetual money machine.

2- Risks in financial markets
- What is risk?
- Measuring risks of financial assets
- Introduction to three different concepts of probability
- History of financial markets, diversification, market risks

3- Introduction to financial risks and its management.
- Relationship between risk and return
- Portfolio theory: the concept of diversification and optimal allocation
- How to price assets: the Capital Asset Pricing Model
- How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4- Financial markets: role and efficiency
- What is an efficient market?
- Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
- Deviations from efficiency, puzzles and anomalies in the financial markets
- Financial bubbles, crashes, systemic instabilities

5- An introduction to Options and derivatives
- Calls, Puts and Shares and other derivatives
- Financial alchemy with options (options are building blocks of any possible cash flow)
- Determination of option value; concept of risk hedging

6- Valuation and using options
- A first simple option valuation model
- The Binomial method for valuing options
- The Black-scholes model and formula
- Practical examples and implementation
- Realized prices deviate from these theories; volatility smile and real option trading
- How to imperfectly hedge with real markets?

7- Real options
- The value of follow-on investment opportunities
- The timing option
- The abandonment option
- Flexible production
- Conceptual aspects and extensions

8- Government bonds and their valuation
- Relationship between bonds and interest rates
- Real and nominal rates of interest
- Term structure and yields to maturity
- Explaining the term structure
- Different models of the term structure

9- Managing international risks
- The foreign exchange market
- Relationships between exchange rates and interest rates, inflation, and other economic variables
- Hedging currency risks
- Currency speculation
- Exchange risk and international investment decisions

Lecture notes
Lecture slides will be available on the site of the lecture

Literature
Corporate finance
Brealey / Myers / Allen
Eight edition

+ additional paper reading provided during the lectures

Prerequisites / Notice
Requirements: sound understanding of stochastic concepts and concepts of mathematical Finance, ability to implement econometric or simulation routines in MATLAB.

401-5820-00L Seminar in Computational Finance for CSE W 4 credits 2S J. Teichmann

Content
We aim to comprehend recent and exciting research on the nature of stochastic volatility: an extensive econometric research [4] lead to new insights on stochastic volatility, in particular that very rough fractional processes of Hurst index about 0.1 actually provide very attractive models. Also from the point of view of pricing [1] and microfoundations [2] these models are very convincing.

More precisely each student is expected to work on one specified task consisting of a theoretical part and an implementation with financial data, whose results should be presented in a 45 minutes presentation.

Literature

Prerequisites / Notice
Requirements: sound understanding of stochastic concepts and concepts of mathematical Finance, ability to implement econometric or simulation routines in MATLAB.
## Electromagnetics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0110-00L</td>
<td>Electromagnetic Waves: Materials, Effects, and Antennas</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

**Abstract**
This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.

**Objective**
You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions. You know how waves interact with matter and about nonlinear and resonant effects. You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.

**Content**
The lecture covers the following topics:
- Generic time-harmonic electromagnetic fields
- Fundamental solutions of the wave equation
- Wave propagation in various types of materials
- Interaction of waves with matter
- Nonlinear effects
- Resonant effects
- Applications like scattering, waveguiding, radiation
- Radio frequency and optical antennas

**Lecture notes**
Lecture notes and slides will be handed out during the lectures.

**Prerequisites / notice**
Remark: the lecture succeeds “Advanced Electromagnetic Waves” and reorientates itself to materials, effects, and applications with waves.

| 227-2037-00L | Physical Modelling and Simulation               | W    | 6    | 4G    | J. Smajic |

**Abstract**
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

**Objective**
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

**Content**
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

| 227-0301-00L | Optical Communication Fundamentals             | W    | 6    | 2V+1U+1P | J. Leuthold |

**Abstract**
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

**Content**
- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

**Lecture notes**
Lecture notes are handed out.

**Literature**
- Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

**Prerequisites / notice**

| 401-4785-00L | Mathematical and Computational Methods in Photonics | W    | 8    | 4G    | H. Ammari |

**Abstract**
The aim of this course is to review new and fundamental mathematical tools, computational approaches, and inversion and optimal design methods used to address challenging problems in nanophotonics. The emphasis will be on analyzing plasmon resonant nanoparticles, super-focusing & super-resolution of electromagnetic waves, photonic crystals, electromagnetic cloaking, metamaterials, and metasurfaces.
The field of photonics encompasses the fundamental science of light propagation and interactions in complex structures, and its technological applications.

The recent advances in nanoscience present great challenges for the applied and computational mathematics community. In nanophotonics, the aim is to control, manipulate, reshape, guide, and focus electromagnetic waves at nanometer length scales, beyond the resolution limit. In particular, one wants to break the resolution limit by reducing the focal spot and confine light to length scales that are significantly smaller than half the wavelength.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare. Light-based technologies can be used effectively for the very early detection of diseases, with non-invasive imaging techniques or point-of-care applications. They are also instrumental in the analysis of processes at the molecular level, giving a greater understanding of the origin of diseases, and hence allowing prevention along with new treatments. Photonic technologies also play a major role in addressing the needs of our ageing society: from pace-makers to synthetic bones, and from endoscopes to the micro-cameras used in in-vivo processes. Furthermore, photonics are also used in advanced lighting technology, and in improving energy efficiency and quality. By using photonic media to control waves across a wide band of wavelengths, we have an unprecedented ability to fabricate new materials with specific microstructures.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonic crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-mathematics in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena. An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

Objective

Knowledge of the fundamentals of electromagnetic theory, development and application of numerical methods for solving Maxwell equations, analysis and optimal design of electromagnetic structures

Autumn Semester 2022

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<tr>
<td>401-5870-00L</td>
<td>Seminar in Electromagnetics for CSE</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>J. Smajic, J. Leuthold</td>
</tr>
</tbody>
</table>

Abstract

Various topics of electromagnetics, including electromagnetic theory, computational electromagnetics, electromagnetic wave propagation, applications from statics to optics. Traditional problems such as antennas, electromagnetic scattering, waveguides, resonators, etc. as well as modern topics such as photonic crystals, metamaterials, plasmonics, etc. are considered.

Objective

The goal of this course is to learn and understand few principal partial differential equations (conservation laws) that are applicable for analysing and modelling of any continuum including the Earth's mantle, core, atmosphere and ocean. By the end of the course, students should be able to write, explain and analyse the equations and apply them for simple analytical cases. Numerical solving of these equations will be discussed in the Numerical Modelling I and II course running in parallel.
A provisional week-by-week schedule (subject to change) is as follows:

Weeks 1,2: The continuity equation

Weeks 3,4: Density and gravity

Weeks 5,6: Stress and strain

Weeks 7,8: The momentum equation

Week 9: Viscous rheology of rocks
Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth's interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws. Exercise: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Weeks 10,11: The heat conservation equation

Week 12,13: Elasticity and plasticity

Week 14: Fluid flow in deforming porous media.

GRADING will be based on homeworks (1/3) and oral exam (2/3).

Lecture notes
Script and Exam questions are available by request tgerya@ethz.ch

Literature

Geophysics: Subject 2

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>651-4241-00L</td>
<td>Numerical Modelling I and II: Theory and Applications</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>T. Gerya</td>
</tr>
</tbody>
</table>

In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasize a hands-on learning approach rather than extensive theory.

The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasize a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.
Content

A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity using stream function/vorticity formulation.


Weeks 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advective in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature


Geophysics: Subject 3
Offered in the spring semester

Geophysics: Subject 4
Offered in the spring semester

Geophysics: Subject 5

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<tr>
<th>Number</th>
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<tr>
<td>651-4014-00L</td>
<td>Seismic Waves II</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>T. Diehl, F. Lanza, A. Obermann</td>
</tr>
</tbody>
</table>

Abstract

This course provides an overview on the most widely used seismological methods to image the Earth's interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Objectives


Geophysics: Subject 6
Offered in the spring semester

Geophysics: Subject 7
Offered in the spring semester

Geophysics: Subject 8

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4273-00L</td>
<td>Numerical Modelling in Fortran</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Tackley</td>
</tr>
</tbody>
</table>

Abstract

This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.
Students should find a project of interest by contacting potential supervisors from the Institute of Geophysics and agree on the content and

Title

analytical competencies

assessed

Students will learn modern quantitative geophysical research by conducting a small original project on a relevant subject.


Computational Biology

Computational Systems Biology

Objective

The seminar in geophysics for CSE is a work on a small research project for 4 credit points. The project can be supervised and graded by any member of the Institute of Geophysics with doctoral degree.

Objective

Students should find a project of interest by contacting potential supervisors from the Institute of Geophysics and agree on the content and timing of the project. At the end of the project, a written report of free format should be submitted by the student, which is then graded by the supervisor.

Lecture notes

No script

Literature

Relevant literature should be provided by the project supervisor.

Taught

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

assessed

Media and Digital Technologies

not assessed

Problem-solving

assessed

Project Management

assessed

Social Competencies

Communication

assessed

Cooperation and Teamwork

assessed

Customer Orientation

not assessed

Leadership and Responsibility

not assessed

Self-presentation and Social Influence

not assessed

Sensitivity to Diversity

not assessed

Negotiation

not assessed

Personal Competencies

Adaptability and Flexibility

not assessed

Creative Thinking

assessed

Critical Thinking

assessed

Integrity and Work Ethics

not assessed

Self-awareness and Self-reflection

not assessed

Self-direction and Self-management

assessed

Media and Digital Technologies

assessed

Problem-solving

assessed

Techniques and Technologies

assessed

Analytical Competencies

assessed

Decision-making

assessed

Media and Digital Technologies

not assessed

Problem-solving

assessed

Project Management

assessed

Communication

assessed

Cooperation and Teamwork

assessed

Customer Orientation

not assessed

Leadership and Responsibility

not assessed

Self-presentation and Social Influence

not assessed

Sensitivity to Diversity

not assessed

Negotiation

not assessed

Adaptability and Flexibility

not assessed

Creative Thinking

assessed

Critical Thinking

assessed

Integrity and Work Ethics

not assessed

Self-awareness and Self-reflection

not assessed

Self-direction and Self-management

assessed

Social Competencies

Objective

The aim of this course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data.

Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.


Biology

Computational Systems Biology

Objective

The aim of the course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

The study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

http://www.csb.ethz.ch/education/lectures.html


Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS.

Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

Deep Learning in Artificial and Biological Neuronal Networks

Deeplearning (DL) is a brain-inspired approach that allows training of large artificial neural networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

After this course students will be able to:

- understand and read the main ideas and methods that are presented in today’s neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to ‘error backpropagation’ in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al. 2015, Silver et al., 2018). ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete communication processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).

2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0250-00L</td>
<td>Solving Partial Differential Equations in Parallel on GPUs</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>L. Räss, S. Omlin, M. Werder</td>
</tr>
</tbody>
</table>

This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on-fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poroelasticity, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.
Analytical Competencies

Creative Thinking

Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of

Assessed

Links to relevant literature will be provided during classes.

By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover,

Visualization, Simulation and Interaction - Virtual

- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation

All topics are illustrated with engineering applications.

Stochastic Methods for Engineers and Natural Scientists

Abstract
The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent

Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling

by the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover,

Content

Probability theory, single and multiple random variables, mappings of random variables
Estimation of statistical moments and probability densities based on data
Stochastic differential equations, Ito calculus, PDF evolution equations
Monte Carlo integration with importance and stratified sampling
Markov-chain Monte Carlo sampling
Control-variate and multi-level Monte Carlo estimation

All topics are illustrated with engineering applications.

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Abstract
The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent

Objective
By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover,
Abstract

Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

Objective

Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

Content

Topics include:
- Review of Bayesian statistics, stochastic systems and Stochastic Optimal Control
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

Lecture notes

Lecture notes will be provided.

Prerequisites / notice

Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended. Background in linear algebra and stochastic systems recommended.

<table>
<thead>
<tr>
<th>Course ID</th>
<th>Course Title</th>
<th>Credits</th>
<th>W</th>
<th>U</th>
<th>A</th>
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</thead>
<tbody>
<tr>
<td>151-0833-00L</td>
<td>Applied Finite Element Analysis</td>
<td>4</td>
<td>W</td>
<td>2V+2U</td>
<td>B. Berisha, D. Mohr</td>
</tr>
<tr>
<td>151-0529-00L</td>
<td>Computational Mechanics II: Nonlinear FEA</td>
<td>4</td>
<td>W</td>
<td>2V+2U</td>
<td>L. De Lorenzis</td>
</tr>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>9</td>
<td>W</td>
<td>3V+2U+3A</td>
<td>T. Hoefler, M. Püschel</td>
</tr>
<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>5</td>
<td>W</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
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Abstract

The goal of the lecture is to provide the students with the fundamentals of the non-linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

Content

- Introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

Lecture notes

Lecture notes will be provided. However, students are encouraged to take their own notes.

Prerequisites / notice

Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended. Background in linear algebra and stochastic systems recommended.

Abstract

The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

Objective

To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

Content

1. Introduction: various sources of non-linearities and implications for FEA.

Lecture notes

Lecture notes will be provided. However, students are encouraged to take their own notes.

Prerequisites / notice

Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

Abstract

Number of participants limited to 125.

Objective

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)* and "Algorithmen und Datenstrukturen (algorithm and data structures)* or equivalent courses.

Data: 18.08.2022 12:39
Autumn Semester 2022
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The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision(graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice

Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

<table>
<thead>
<tr>
<th>227-0102-00L</th>
<th>Discrete Event Systems</th>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>L. Josipovic, L. Vanbever, R. Wattenhofer</th>
</tr>
</thead>
</table>

**Abstract**
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

**Objective**
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

**Content**
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

**Lecture notes**
Available

**Literature**
- [bertsekas] Data Networks
  Dimitri Bertsekas, Robert Gallager

- [borodin] Online Computation and Competitive Analysis
  Allan Borodin, Ran El-Yaniv.
  Cambridge University Press, 1998

- [boudec] Network Calculus
  J.-Y. Le Boudec, P. Thiran
  Springer, 2001

- [cassandras] Introduction to Discrete Event Systems
  Christos Cassandras, Stéphane Lafortune.

- [fiat] Online Algorithms: The State of the Art
  A. Fiat and G. Woeginger

  D. Hochbaum

- [schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitsrechnung und Statistik)
  T. Schikinger, A. Steger
  Springer, Berlin, 2001

- [sipser] Introduction to the Theory of Computation
  Michael Sipser

**227-0116-00L**

**Abstract**
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

**Objective**
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.
Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
  - Register Transfer Level (RTL) synthesis and its limitations.
  - Building blocks of digital VLSI circuits.
  - Functional verification techniques and their limitations.
  - Modular and largely reusable testbenches.
  - Assertion-based verification.
  - Synchronous versus asynchronous circuits.
  - The case for synchronous circuits.
  - Periodic events and the Anceau diagram.
  - Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Literature

Prerequisites / notice
Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/


Abstract
This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

Objective
At the end of this course, you will
- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

Content
The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:
- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasites
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

227-0417-00L  Information Theory I  W  6 credits  4G  A. Lapidoth

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
The fundamentals of Information Theory including Shannon’s source coding and channel coding theorems

Content
The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

227-0124-00L  Embedded Systems  W  6 credits  4G  M. Magno, L. Thiele

Abstract
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.
### Objective
Understanding specific requirements and problems arising in embedded system applications.

### Content
Understanding architectures and components, their hardware-software interfaces, the memory architecture, communication between components, embedded operating systems, real-time scheduling theory, shared resources, low-power and low-energy design as well as hardware architecture synthesis.

Using the formal models and methods in embedded system design in practical applications using the programming language C, the operating system FreeRTOS, a commercial embedded system platform, and the associated design environment.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems FreeRTOS, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically, the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at [https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html](https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html).

### Lecture notes
The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at [https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html](https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html).

### Literature


### Prerequisites / notice
Prerequisites: Basic knowledge in computer architectures and programming.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>W</th>
<th>Credits</th>
<th>ECTS</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0971-00L</td>
<td>Computational Psychiatry</td>
<td>W</td>
<td>3 credits</td>
<td>4S</td>
<td>K. Stephan</td>
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<tr>
<td></td>
<td>Please note that participation in this course and the practical sessions requires additional registration at: <a href="http://www.translationalneuromodeling.org/cpcourse/">http://www.translationalneuromodeling.org/cpcourse/</a></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.</td>
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<td><strong>Objective</strong></td>
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<td>This course aims at bridging the gap between mathematical modelers and clinical neuroscientists by teaching computational techniques in the context of clinical applications. The hope is that the acquisition of a joint language and tool-kit will enable more effective communication and joint translational research between fields that are usually worlds apart.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see <a href="http://www.translationalneuromodeling.org/cpcourse/">http://www.translationalneuromodeling.org/cpcourse/</a> for details.</td>
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<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
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<td></td>
<td>Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection</td>
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<td><strong>Abstract</strong></td>
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<td>After this course, students will:</td>
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<td></td>
<td>Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.</td>
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<td>Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.</td>
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<td>Be able to learn new languages more rapidly.</td>
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<td>Be aware of many subtle problems of object-oriented programming and know how to avoid them.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.</td>
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<td>The topics discussed in the course include among others:</td>
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<td></td>
<td>The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)</td>
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<td>The key problems of single and multiple inheritance and how different languages address them</td>
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<td>Generic type systems, in particular, Java generics, C# generics, and C++ templates</td>
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<td>The situations in which object-oriented programming does not provide encapsulation, and how to avoid them</td>
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<td></td>
<td>The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing</td>
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<td>How to maintain the consistency of data structures</td>
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<td></td>
<td><strong>Literature</strong></td>
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<td>Will be announced in the lecture.</td>
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<td>Prerequisites:</td>
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<td>Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience</td>
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<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>A. Steger</td>
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<td>Las Vegas &amp; Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.</td>
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</table>
Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes
Yes

Literature

252-0543-01L Computer Graphics W 8 credits 3V+2U+2A M. Gross, M. Papas

Abstract
This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

Objective
At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

Content
This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

Lecture notes
no

Literature
Books:
High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
Multiple view geometry in computer vision
Physically Based Rendering: From Theory to Implementation

Prerequisites / notice
Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.
The programming assignments will be in C++. This will not be taught in the class.

252-0546-00L Physically-Based Simulation in Computer Graphics W 5 credits 2V+1U+1A S. Coros, B. Thomaszewski

Abstract
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Content
The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Prerequisites / notice
Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

401-3621-00L Fundamentals of Mathematical Statistics W 10 credits 4V+1U S. van de Geer

Abstract
The course covers the basics of inferential statistics.

Objective
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

Content
The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

Literature

Prerequisites / notice
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

401-3627-00L High-Dimensional Statistics W 4 credits 2V P. L. Bühlmann

Abstract
"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Objective
Knowledge of methods and basic theory for high-dimensional statistical inference

Content
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and II-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

Literature

401-4623-00L Time Series Analysis W 4 credits 2G N. Meinshausen

Abstract
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

Literature
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice
Basic knowledge in probability and statistics

401-3901-00L Linear & Combinatorial Optimization W 11 credits 4V+2U R. Zenklusen

Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1778 of 2345
Objective

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.


Prerequisites / notice

Solid background in linear algebra.

Literature


401-4944-20L Mathematics of Data Science

W 8 credits 4G A. Bandeira

Abstract

Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

Objective

Introduction to various mathematical aspects of Data Science.

Content

These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

Lecture notes


Prerequisites / notice

The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity--including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and 227-0434-10L Mathematics of Information” taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

227-0423-00L Neural Network Theory

W 4 credits 2V+1U H. Bölcskei

Abstract

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

Content

1. Universal approximation theorem with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning
This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (diifferential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

327-1201-00L Transport Phenomena I

Abstract
Phenomenological approach to "Transport Phenomena" based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

Objective
The teaching goals of this course are on five different levels:
(1) Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling, ...
(2) Ability to use the fundamental concepts in applications
(3) Insight into the role of boundary conditions (mainly part 2)
(4) Knowledge of a number of applications
(5) Flavor of numerical techniques: finite elements and finite differences.

Content
Part 1 Approach to Transport Phenomena
Equilibrium Thermodynamics
Balance Equations
Forces and Fluxes
Applications
1. Measuring Transport Coefficients
2. Fluid mechanics
3. Combined heat and flow

Lecture notes

Literature

Prerequisites / notice

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Problem-solving

252-3005-00L Natural Language Processing

Abstract
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective
The objective of the course is to teach the basic concepts in the statistical processing of natural languages. The course will be project-based so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.
Abstract
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

Content
The course is split into 3 parts:

Robustness in Deep Learning
- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning
- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning
- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


Prerequisites / notice
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Case Studies

Table: Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3667-72L</td>
<td>Case Studies Seminar (Autumn Semester 2022)</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>V. C. Gradinaru, R. Hiptmair</td>
</tr>
</tbody>
</table>

Abstract
Invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list. Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

Content
In the CSE Case Studies Seminar invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list (containing articles from, e.g., Nature, Science, Scientific American, etc.). If the underlying paper comprises more than 15 pages, two or three consecutive case studies presentations delivered by different students can be based on it. Consistency in layout, style, and contents of those presentations is expected.

Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

Prerequisites / notice
The talks might be given via Zoom; talks in presence should be also streamed in Zoom.

75% attendance and a short presentation on a published paper out of a list or on some own project are mandatory.

Students have to register their presentations online until the second Wednesday of the semester on https://rw.ethz.ch/the-programme/case-studies.html

The student talks will be grouped by subject, so we'll decide the actual dates of the individual talks.

Students that realize that they will not fulfill this criteria have to contact the teaching staff or de-register before the end of semester from the Seminar if they want to avoid a "Fail" in their documents. Later de-registrations will not be considered.
Taught competencies

Subject-specific Competencies

- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies

- Social Competencies
  - Communication
- Personal Competencies
  - Cooperation and Teamwork

Social Competencies

- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Analytical Competencies

- Social Competencies
  - Communication
- Personal Competencies
  - Cooperation and Teamwork

Personal Competencies

- Social Competencies
  - Communication
- Personal Competencies
  - Cooperation and Teamwork

Semester Paper

There are several course units “Semester Paper” that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3740-01L</td>
<td>Semester Paper</td>
<td>W</td>
<td>8</td>
<td>11A</td>
<td>Supervisors</td>
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<tr>
<td></td>
<td>Successful participation in the course unit 401-2000-00L</td>
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<td>Scientific Works in Mathematics or 402-2000-00L</td>
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<td>Scientific Works in Physics is required.</td>
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<tr>
<td>Abstract</td>
<td>Semester Papers help to deepen the students' knowledge of a specific subject area. Students are offered a selection of topics. These papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing.</td>
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<td>Objective</td>
<td>Semester papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>There are several course units &quot;Semester Paper&quot; that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.</td>
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<tr>
<td>401-3740-02L</td>
<td>Semester Paper (No. 2)</td>
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<td>8</td>
<td>11A</td>
<td>Supervisors</td>
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<td></td>
<td>Successful participation in the course unit 401-2000-00L</td>
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<td></td>
<td>Scientific Works in Mathematics or 402-2000-00L</td>
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<td></td>
<td>Scientific Works in Physics is required.</td>
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<tr>
<td>Abstract</td>
<td>Semester Papers help to deepen the students' knowledge of a specific subject area. Students are offered a selection of topics. These papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing.</td>
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Science in Perspective

Two credits are needed from the “Science in Perspective” programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree. see https://ethz.ch/content/dam/ethz/common/docs/weisungssammlung/files-en/science-in-perspective.pdf (Eight credits must be acquired in this category; normally six during the Bachelor’s degree programme, and two during the Master's degree programme. A maximum of three credits from language courses from the range of the Language Center of the University of Zurich and ETH Zurich may be recognised. In addition, only advanced courses (level B2 upwards) in the European languages English, French, Italian and Spanish are recognised. German language courses are recognised from level C2 upwards.)

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-MATH
- see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Mathematics</td>
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<td>D. Possamai</td>
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<tr>
<td>Target audience:</td>
<td>Third year Bachelor students:</td>
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<tr>
<td>Master students who cannot document to have received</td>
<td>an adequate training in working scientifically.</td>
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<tr>
<td>Abstract</td>
<td>Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)</td>
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</table>
Objective
Learn the basic standards of scientific works in mathematics.

Content
- Types of mathematical works
- Publication standards in pure and applied mathematics
- Data handling
- Ethical issues
- Citation guidelines

Prerequisites / notice

401-2000-01L Lunch Sessions – Thesis Basics for Mathematics
Students
Details and registration for the optional MathBib training course: https://www.math.ethz.ch/mathbib-schulungen

Abstract
Optional MathBib training course

402-2000-00L Scientific Works in Physics
Target audience:
Master students who cannot document to have received an adequate training in working scientifically.

Abstract

401-4990-01L Master's Thesis
Only students who fulfil the following criteria are permitted to commence the Master's thesis:

a. successful completion of the Bachelor's programme;

b. fulfilling of any additional requirements necessary to gain admission to the Master's programme;

c. successful completion of
   1) at least two course units in the category 'Core courses';
   2) at least five course units, including a seminar, in the category 'Fields of specialisation'; and
   3) the semester paper.

Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics or 402-2000-00L Scientific Works in Physics is required.

For more information, see www.math.ethz.ch/intranet/students/study-administration/theses.html

Abstract
The master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective
Thesis work should prove the students' ability to independent, structured and scientific working.

Colloquia

Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

Analysis III
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.
Content

Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Literature


For reference/complement of the Analysis I/II courses:

Christian Blatter: Ingenieur-Analysis (Download PDF)

Prerequisites / notice

Up-to-date information about this course can be found at: http://www.math.ethz.ch/education/bachelor/lectures/hs2013/other/analysis3_itet406-0603-AAL

Stochastics (Probability and Statistics)

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective

The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content

From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature

- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Numerical Methods for CSE

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

E- 4 credits 9R M. Kalisch

406-0603-AAL

E- 9 credits 19R R. Hiptmair

401-2673-AAL

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1984 of 2345
Abstract
The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently

Content
* Direct Methods for linear systems of equations
* Least Squares Techniques
* Data Interpolation and Fitting
* Filtering Algorithms
* Approximation of Functions
* Numerical Quadrature
* Iterative Methods for non-linear systems of equations

Lecture notes
Lecture materials (PDF documents and codes) will be made available to participants.

Literature


M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice
Solid knowledge about fundamental concepts and techniques from linear algebra & calculus as taught in the first year of science and engineering curricula.

The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves.

401-0674-AAL Numerical Methods for Partial Differential Equations E- 10 credits 21R R. Hiptmair
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Derivation, properties, and implementation of fundamental numerical methods for a few key partial differential equations: convection-diffusion, heat equation, wave equation, conservation laws. Implementation in C++ based on a finite element library.

Objective
Main skills to be acquired in this course:
* Ability to implement fundamental numerical methods for the solution of partial differential equations efficiently.
* Ability to modify and adapt numerical algorithms guided by awareness of their mathematical foundations.
* Ability to select and assess numerical methods in light of the predictions of theory
* Ability to identify features of a PDE (= partial differential equation) based model that are relevant for the selection and performance of a numerical algorithm.
* Ability to understand research publications on theoretical and practical aspects of numerical methods for partial differential equations.
* Skills in the efficient implementation of finite element methods on unstructured meshes.

This course is neither a course on the mathematical foundations and numerical analysis of methods nor an course that merely teaches recipes and how to apply software packages.
1 Case Study: A Two-point Boundary Value Problem [optional]

1.1 Introduction
1.2 A model problem
1.3 Variational approach
1.4 Simplified model
1.5 Discretization
1.5.1 Galerkin discretization
1.5.2 Collocation [optional]
1.5.3 Finite differences
1.6 Convergence

2 Second-order Scalar Elliptic Boundary Value Problems
2.1 Equilibrium models
2.1.1 Taut membrane
2.1.2 Electrostatic fields
2.1.3 Quadratic minimization problems
2.2 Sobolev spaces
2.3 Variational formulations
2.4 Equilibrium models: Boundary value problems
3 Finite Element Methods (FEM)
3.1 Galerkin discretization
3.2 Case study: Triangular linear FEM in two dimensions
3.3 Building blocks of general FEM
3.4 Lagrangian FEM
3.4.1 Simplicial Lagrangian FEM
3.4.2 Tensor-product Lagrangian FEM
3.5 Implementation of FEM in C++
3.5.1 Mesh file format (Gmsh)
3.5.2 Mesh data structures (DUNE)
3.5.3 Assembly
3.5.4 Local computations and quadrature
3.5.5 Incorporation of essential boundary conditions
3.6 Parametric finite elements
3.6.1 Affine equivalence
3.6.2 Example: Quadrilateral Lagrangian finite elements
3.6.3 Transformation techniques
3.6.4 Boundary approximation
3.7 Linearization [optional]
4 Finite Differences (FD) and Finite Volume Methods (FV) [optional]
4.1 Finite differences
4.2 Finite volume methods (FVM)
5 Convergence and Accuracy
5.1 Galerkin error estimates
5.2 Empirical Convergence of FEM
5.3 Finite element error estimates
5.4 Elliptic regularity theory
5.5 Variational crimes
5.6 Duality techniques [optional]
5.7 Discrete maximum principle [optional]
6 2nd-Order Linear Evolution Problems
6.1 Parabolic initial-boundary value problems
6.1.1 Heat equation
6.1.2 Spatial variational formulation
6.1.3 Method of lines
6.1.4 Timestepping
6.1.5 Convergence
6.2 Wave equations [optional]
6.2.1 Vibrating membrane
6.2.2 Wave propagation
6.2.3 Method of lines
6.2.4 Timestepping
6.2.5 CFL-condition
7 Convection-Diffusion Problems [optional]
7.1 Heat conduction in a fluid
7.1.1 Modelling fluid flow
7.1.2 Heat convection and diffusion
7.1.3 Incompressible fluids
7.1.4 Transient heat conduction
7.2 Stationary convection-diffusion problems
7.2.1 Singular perturbation
7.2.2 Upwinding
7.3 Transient convection-diffusion BVP
7.3.1 Method of lines
7.3.2 Transport equation
7.3.3 Lagrangian split-step method
7.3.4 Semi-Lagrangian method
8 Numerical Methods for Conservation Laws
8.1 Conservation laws: Examples
8.2 Scalar conservation laws in 1D
8.3 Conservative finite volume discretization
8.3.1 Semi-discrete conservation form
8.3.2 Discrete conservation property
8.3.3 Numerical flux functions
8.3.4 Mointone schemes
8.4 Timestepping
8.4.1 Linear stability
8.4.2 CFL-condition
8.4.3 Convergence
8.5 Higher order conservative schemes [optional]
8.5.1 Slope limiting
8.5.2 MUSCL scheme
8.6. FV-schemes for systems of conservation laws [optional]

“optional” indicates that the corresponding topic might be skipped depending on the progress of the course.

Lecture notes
- The lecture will be taught in flipped classroom format.
- Video tutorials for all thematic units will be published online.
- Solution of homework problems will partly be covered by video tutorials.
- Lecture documents and tablet notes accompanying the videos will be made available to the audience as PDF.

Literature
- Chapters of the following books provide supplementary reading (detailed references in course material):

However, study of supplementary literature is not important for following the course.

Prerequisites / notice
- Mastery of basic calculus and linear algebra is taken for granted.
- Familiarity with fundamental numerical methods (solution methods for linear systems of equations, interpolation, approximation, numerical quadrature, numerical integration of ODEs) is essential.
- Important: Coding skills and experience in C++ are essential.

Homework assignments involve substantial coding, partly based on a C++ finite element library. The written examination will be computer based and will comprise coding tasks.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>PR</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>252-0232-AAL</td>
<td>Software Engineering</td>
<td>6 credits</td>
<td>13R</td>
<td>F. O. Friedrich Wicker, M. Schwerhoff</td>
</tr>
</tbody>
</table>

Abstract
This course introduces both theoretical and applied aspects of software engineering. It covers:

- Software Architecture
- Informal and formal Modeling
- Design Patterns
- Software Engineering Principles
- Code Refactoring
- Program Testing

Objective
The course has two main objectives:

- Obtain an end-to-end (both, theoretical and practical) understanding of the core techniques used for building quality software.
- Be able to apply these techniques in practice.

Content
While the lecture will provide the theoretical foundations for the various aspects of software engineering, the students will apply those techniques in project work that will span over the whole semester - involving all aspects of software engineering, from understanding requirements over design and implementation to deployment and change requests.

Literature
Will be announced in the lecture
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

The course will give you an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

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Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of microrobotics for applications in medicine and additive manufacturing.

Objective

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices.

Lecture notes


Literature


Prerequisites / notice

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making not assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-direction and Self-management assessed

151-0563-01L Dynamic Programming and Optimal Control

Introduction to Dynamic Programming and Optimal Control.

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.


The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

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Lecture notes


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Prerequisites / notice

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Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making not assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-direction and Self-management assessed

151-0593-00L Embedded Control Systems

This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.


The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Objective

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices.

Lecture notes


Literature


Prerequisites / notice

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making not assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-direction and Self-management assessed

151-0601-00L Theory of Robotics and Mechatronics

This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Objective

Robots are used in a variety of fields, including robotics, computer vision, and control. This course provides an introduction to the theory of robotics, covers the fundamentals of the field, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Content

This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Lecture notes

Available.

Prerequisites / notice

151-0604-00L Microrobotics

Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Objective

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices.

Lecture notes


Literature


Prerequisites / notice

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making not assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Critical Thinking assessed

Integrity and Work Ethics assessed

Self-direction and Self-management assessed

151-0563-01L Dynamic Programming and Optimal Control

W 4 credits 2V+1U R. D’Andrea

Abstract

Introduction to Dynamic Programming and Optimal Control.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature


Prerequisites / notice

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

151-0593-00L Embedded Control Systems

W 4 credits 6G C. Onder, M. Schmid Daners

Abstract

This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

Objective

Familiarize students with main architectural principles and concepts of embedded control systems.

Content

An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Lecture notes

Lecture notes, lab instructions, supplemental material

Prerequisites / notice

Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch) After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

151-0601-00L Theory of Robotics and Mechatronics

Does not take place this semester.

W 4 credits 3G

Abstract

This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Objective

Robots are used in a variety of fields, including robotics, computer vision, and control. This course provides an introduction to the theory of robotics, covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Content

An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Lecture notes

Available.

151-0604-00L Microrobotics

W 4 credits 3G B. Nelson

Abstract

Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.
Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrodynamics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

| Code     | Title                                                                 |
|----------|                                                                      |
| 151-0632-00L | Vision Algorithms for Mobile Robotics (University of Zurich) |
| 151-0851-00L | Robot Dynamics |
| 151-0632-00L | Aircraft aerodynamics |

Literature

Prerequisites / notice
Note: If you are interested in taking UZH courses, you must register as an incoming mobility student at UZH. For details, see as follows:

- UZH course enrollment for ETH student at University of Zurich (UZH) > Mobility within Switzerland – Incoming > Module Mobility: The easiest way to take individual modules/courses to supplement your studies at your home university is with module mobility. This option is not available to students who have dropped out of their home university or have been definitely excluded or banned from the relevant program.
- Application and Deadlines: Applications are submitted via the UZH application portal (https://www.uzh.ch/cmsssl/en/studies/application/deadline.html)

ATTENTION: When you book the course at UZH, you are automatically registered for the exam at UZH and you can unregister until the October deadline. After registering for the course, you as an ETH student need to check out your “UZH email account” to receive the related information from the lecturer.

151-0851-00L Robot Dynamics

Abstract
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

Objective
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content
The course consists of three parts: First, we will refresh and deepen the student’s knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will be used from the courses on mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. The student will learn how to model the propulsion system, aerodynamics of the propellers, introduction to static longitudinal stability.

Prerequisites / notice
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

151-1116-00L Aircraft aerodynamics

Abstract
An introduction to the basic principles and interrelations of aircraft and automotive aerodynamics.

Objective
To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components. Illustration of the intrinsic problems and results using examples. Using experimental and theoretical methods to illustrate possibilities and limits.

Content
Aerodynamics: atmosphere, aerodynamic forces (ascending force; profile, wings, Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.


Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1990 of 2345
**Lecture notes**
Preparation materials & slides are provided prior to each class

**Literature**
Aircraft Aerodynamics:
- Schlichting H. und Truckenbrodt, E: Aerodynamik des Flugzeuges (Bd I und II), Springer Verlag, 1960
- Hoerner, S.F.: Fluid Dynamic Lift, Hoerner Fluid Dynamics, 1975

Vehicle Aerodynamics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>151-0532-00L</td>
<td>Nonlinear Dynamics and Chaos I</td>
<td>W 4</td>
<td>2V+2U</td>
<td>G. Haller</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.</td>
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<td><strong>Objective</strong></td>
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<td>This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.</td>
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<td>(2) Near equilibrium dynamics: Linear and Lyapunov stability</td>
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<td>(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations</td>
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<td>(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.</td>
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<td>(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance</td>
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<td><strong>Lecture notes</strong></td>
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<td>The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>- Prerequisites: Analysis, linear algebra and a basic course in differential equations.</td>
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<td>- Exam: two-hour written exam in English.</td>
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<td>- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.</td>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-9905-00L</td>
<td>Applied Compositional Thinking for Engineers II</td>
<td>W 4</td>
<td>3G</td>
<td>A. Censi, J. Lorand</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>This course is an introduction to advanced topics in Applied Category Theory focused on the need of applications. The course favors a computational, constructive, and compositional approach targeted to specific applications in engineering. In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of the problem and the design of the solution. However, the problem is that the type of math which could be useful to applications is not traditionally taught. Applied Category Theory is a new field of mathematics that could help thinking about compositionality. However, there exists no easy path for learning it for engineers that is approachable and shows practical applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I), offered in Spring 2021. This course’s goal is not to teach category theory for the sake of it. Rather, we will teach the “compositionality way of thinking”; category theory will be just the means towards it. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications. The course will favor a computational/constructive approach, highlighted even more in the second part of the class; each concept is accompanied by concrete exercises in the programming language Python. The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.</td>
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</tbody>
</table>
Functors

Co-design problems

Naturality:
- Natural transformations
- Adjunctions
- Traced monoidal categories

- Computation:
  - From mathematical models to algorithms
  - Solving finite co-design problems
  - Monads
  - Modeling uncertainty

Enriched category theory:
- Profunctors
- Enriched categories
- Negative category theory

Wirings:
- Operads
- Wiring diagrams

Linear logic
- Linear logic and DP

Lecture notes
Slides and notes will be provided.

Literature

Prerequisites / notice
The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Algebra (sets, posets, relations, semigroups, groups).
3) Python programming.

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in Spring Semester are sufficiently proficient in (1)-(3).

227-0102-00L Discrete Event Systems W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes
Available
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems FreeRTOS, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://www.tec.ee.ethz.ch/education/lectures/embedded-systems.html.
### Course Details

#### 227-0225-00L Linear System Theory
**Prerequisites / notice:**
- Basic knowledge in computer architectures and programming.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.</td>
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</table>

**Abstract:**
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

**Literature:**

**Prerequisites / notice:**
- Subject-specific Competencies: Concepts and Theories, assessed.
- Method-specific Competencies: Analytical Competencies, assessed.
- Problem-solving: Critical Thinking, not assessed.

**Lecture notes:**
Available on the course Moodle platform.

#### 227-0247-00L Power Electronic Systems I
**Prerequisites / notice:**
- Introductory course on power electronics is recommended.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>Basics of the switching behavior, gate drive and snubber circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications.</td>
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</table>

**Abstract:**
Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related processes of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

**Literature:**

**Prerequisites / notice:**
- Subject-specific Competencies: Concepts and Theories, assessed.
- Method-specific Competencies: Analytical Competencies, assessed.
- Problem-solving: Critical Thinking, not assessed.

**Lecture notes:**
Lecture notes and associated exercises including correct answers.

#### 227-0447-00L Image Analysis and Computer Vision
**Prerequisites / notice:**
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.</td>
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</table>

**Abstract:**

**Literature:**
- J. Biela: Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Prerequisites / notice:**
- Course material Script, computer demonstrations, exercises and problem solutions
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

**Lecture notes:**
Course material Script, computer demonstrations, exercises and problem solutions

**Prerequisites:**
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

**Lecture notes:**
Course material Script, computer demonstrations, exercises and problem solutions

#### 227-0526-00L Power System Analysis
**Prerequisites / notice:**
- Sufficient mathematical maturity, in particular in linear algebra, analysis.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.</td>
<td></td>
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</tbody>
</table>

**Abstract:**
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Literature:**

**Prerequisites / notice:**
- Subject-specific Competencies: Concepts and Theories, assessed.
- Method-specific Competencies: Analytical Competencies, assessed.
- Problem-solving: Critical Thinking, not assessed.

**Lecture notes:**
Lecture notes and associated exercises including correct answers.

**Prerequisites:**
- Introductory course on power electronics is recommended.
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit</th>
<th>Lecture</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>227-0689-00L</td>
<td>System Identification</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
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<td>R. Smith</td>
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<td></td>
<td>Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.</td>
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<td>To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.</td>
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<td>Additional papers will be available via the course Moodle.</td>
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<td></td>
<td>Control systems (227-0216-00L) or equivalent.</td>
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<tr>
<td>227-0697-00L</td>
<td>Industrial Process Control</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
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<td>A. Horch, L. Dominguez Palomeque</td>
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<td></td>
<td>Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing. General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends.</td>
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<td>Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.</td>
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<td>Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text); PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.</td>
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<td>Automation standards: Communication, Architecture, Engineering, dependable systems, functional safety, automation security. Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.</td>
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<td>References will be given at the end of individual lectures.</td>
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<td>Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.</td>
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<tr>
<td>227-0920-00L</td>
<td>Seminar in Systems and Control</td>
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<td>0 credits</td>
<td>1S</td>
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<td>F. Dörfler, R. D'Andrea, E. Frazzoli, M. H. Khammash, J. Lygeros, R. Smith</td>
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<tr>
<td></td>
<td>Current topics in Systems and Control presented mostly by external speakers from academia and industry</td>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
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<td></td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
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<td></td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
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<td></td>
<td>Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.</td>
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<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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<td>Topics covered in the lecture include:</td>
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<td>Fundamentals:</td>
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<td>What is data?</td>
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<td></td>
<td>Bayesian Learning</td>
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<td></td>
<td>Computational learning theory</td>
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<td></td>
<td>Supervised learning:</td>
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<td>Ensembles: Bagging and Boosting</td>
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<td></td>
<td>Max Margin methods</td>
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<td></td>
<td>Neural networks</td>
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<tr>
<td></td>
<td>Unsupervised learning:</td>
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<tr>
<td></td>
<td>Dimensionality reduction techniques</td>
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<tr>
<td></td>
<td>Clustering</td>
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<tr>
<td></td>
<td>Mixture Models</td>
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<td></td>
<td>Non-parametric density estimation</td>
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<td></td>
<td>Learning Dynamical Systems</td>
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</tbody>
</table>

Lecture notes

No lecture notes, but slides will be made available on the course webpage.
### Probabilistic Artificial Intelligence

*This seminar covers advanced topics in computer vision by reading and presenting classic and state-of-the-art papers.*

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5210-00L</td>
<td><strong>Probabilistic Artificial Intelligence</strong></td>
<td>8 credits</td>
<td>This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics. The course is designed for graduate students.</td>
</tr>
</tbody>
</table>

### Human Computer Interaction

*The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve students' presentations and critical analysis skills.*

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-5051-00L</td>
<td><strong>Advanced Topics in Machine Learning</strong></td>
<td>2 credits</td>
<td>The seminar &quot;Advanced Topics in Machine Learning&quot; familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.</td>
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</table>

### Seminar in Advanced Topics in Vision

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>252-5701-00L</td>
<td><strong>Seminar in Advanced Topics in Vision</strong></td>
<td>2 credits</td>
<td>This seminar covers advanced topics in computer vision such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics.</td>
</tr>
</tbody>
</table>
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

2V+2U

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual

I. Armeni

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the

M. Pollefeys

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

263-5902-00L Computer Vision W 8 credits 3V+1U+3A M. Pollefeys, S. Tang, F. Yu

Abstract
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve these.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to compute of the sense of computer vision literature.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

263-5905-00L Mixed Reality W 5 credits 3G+1A I. Armeni, M. Pollefeys

Abstract
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Objective
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding of the main concepts and techniques used to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

Content
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

Introduction to Mixed Reality / Augmented Reality / Virtual Reality

Prerequisites / notice
Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

376-1504-00L Physical Human Robot Interaction (pHRI) ■ W 4 credits 2V+2U O. Lambercy

Abstract
This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

Objective
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) Identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) Compare and select mechatronic components that optimally fulfill the defined design requirements;
3) Derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) Design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) Characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) Investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content
This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory stimuli (relating, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/ virtual coupling, friction, damping, time delays, sampling rates, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes
Will be distributed on Moodle before the lectures.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 1997 of 2345
Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems Biology, reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks. Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the term "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for analyzing temporal changes of biological networks, and (v) stochastic simulation methods (e.g., Gillespie's algorithm). Together, these methods form the fundamental techniques of systems biology and are essential for the analysis and control of complex biological systems.

The students are expected to have basic control knowledge from previous classes. The lecture will be held in English.

There are 4 credit points for this lecture.

Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msr.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.

Autumn Semester 2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Prerequisites / notice</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0623-00L</td>
<td>ETH Zurich Distinguished Seminar in Robotics, Systems and Controls</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>B. Nelson, M. Hutter, R. Katzschmann, R. Riener, R. Siegwart</td>
</tr>
</tbody>
</table>

Abstract: This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

Objective: Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msr.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.

Multidisciplinary Courses

Any courses offered by the Departments of MAVT, ITET or INFK. Your tutor must agree to this choice.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 1998 of 2345
This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be monitored. If for some reason a student cannot attend one of the lectures, the student must select another ETH or University of Zurich seminar related to the field and submit a one-page description of the seminar topic. Please see http://www.msr.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a suggestion of other lectures.

Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one-page summary of the attended lecture. No exceptions to this rule are allowed.

**Science in Perspective**

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-MAVT
- see Science in Perspective: Language Courses ETH/UZH

**Semester Project**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1014-00L</td>
<td>Semester Project Robotics, Systems and Control Only for Robotics, Systems and Control MSc.</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

The subject of the Semester Project and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

**Abstract**
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

**Objective**
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program.

**Industrial Internship**

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship Access to the company list and request for recognition under <a href="http://www.mavt.ethz.ch/praxis">www.mavt.ethz.ch/praxis</a>.</td>
<td>O</td>
<td>8 credits</td>
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<td>external organisers</td>
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No registration required via myStudies.

**Abstract**
The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

**Objective**
The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

**Master's Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-1016-00L</td>
<td>Master's Thesis Robotics, Systems and Control Students who fulfill the following criteria are allowed to begin with their Master's Thesis: a. successful completion of the bachelor program; b. fulfilling of any additional requirements necessary to gain admission to the master programme; c. successful completion of the semester project; d. achievement of 28 ECTS in the category &quot;Core Courses&quot;. The Master's Thesis must be approved in advance by the tutor and is supervised by a professor of ETH Zurich or an adjunct faculty of RSC.</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
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</table>

Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

**Objective**
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

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## Robotics, Systems and Control Master - Key for Type

<table>
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<tr>
<th>O</th>
<th>W+</th>
<th>W</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
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<tbody>
<tr>
<td>Compulsory</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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## Key for Hours

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<th>V</th>
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<th>S</th>
<th>K</th>
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<tbody>
<tr>
<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<th>A</th>
<th>D</th>
<th>R</th>
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<tbody>
<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Principles of Microeconomics

T. Bernauer

Course materials will be made available via Moodle.

The course Policy Analysis 1 will introduce important concepts and methods for ex-ante policy analysis. It will mostly focus on the policy analysis of developing and implementing own surveys with a focus on causal inference via survey experiments. Finally, we give practical insights into the analysis of (complex) survey data.

The goals of this class are:
- to understand the basics of public opinion research
- to translate this theoretical knowledge into the practical design and implementation of surveys
- to make use of survey experiments for causal inference

At the end of the course, students should be able to use and evaluate public opinion data and design survey experiments to test policy-relevant questions.

Cornerstone Science, Technology, and Policy

T. Bernauer

This course introduces students to the MSc STP programme. It provides a general introduction to the study of STP.

This course introduces students to the STP programme in two ways. First, it provides a general introduction to the study of STP. Second, it exposes students to various complex policy problems and ways and means of coming up with proposals for and assessments of policy options.

In a reading workshop, students will learn how to improve their skills in reading and understanding scientific papers in English.

- Introduction to Science, Technology and Policy.
- Reading Workshop: Reading and understanding scientific papers in English.

A detailed programme will be sent out to the participants in advance to the course.

Designing and Implementing Public Opinion Surveys and Experiments

L. P. Fesenfeld, S. Gomm, E. K. Smith

The course teaches the basics of public opinion surveys. We start with the theoretical foundations of the formation of (public) opinion formation and ideology, then turn to the practical lessons of developing and implementing own surveys with a focus on causal inference via survey experiments. Finally, we give practical insights into the analysis of (complex) survey data.

At the end of the course, students should be able to use and evaluate public opinion data and design survey experiments to test policy-relevant questions.

Colloquium Science, Technology, and Policy (HS)

B. Steffen, F. M. Egli, T. Schmidt

The course is open to ISTP's MSc students and to ISTP doctoral students.

Policy Analysis

B. Steffen, F. M. Egli, T. Schmidt

Students should gain the skill to perform policy analyses independently. To this end, students will be enabled to understand a policy problem and the rationale for policy intervention; to select appropriate impact categories and methods to address a policy problem through policy analysis; to assess policy alternatives, using various ex-ante policy analysis methods; and to communicate the results of the analysis.

The course has four major topics:
- Rationales for public policy in Science and Technology
- Impact of policies on firms and investors
- Impacts of policies on socio-technical systems
- Impact of policies on society at large

Principles of Microeconomics

M. Filippini

The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

LECTURE NOTES

Lecture notes, exercises and reference material can be downloaded from Moodle.


The book can also be used for the course "Principles of Macroeconomics" (Sturm)


Complementary:


GESE (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.


- International trade
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- Public sector, tax system
- Market failures, common resources and public goods

This course covers the necessary fundamentals for the use of statistics to understand policy. Theoretically the course will provide a survey of foundational concepts and techniques statistics and mathematics. The applied part of the course will focus on implementing these techniques in R, as well as the practical skills required to develop their own data based research projects.

Objective

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
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Complementary:


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The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

Objective
Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Lecture notes
Powerpoint slides are available on the webpage. Additional documents are handed out as copies.

Literature
Basic literature and references are listed on the webpage.

Prerequisites / notice
The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

363-1047-00L Urban Systems and Transportation

Abstract
This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

Objective
The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

Content
The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

Lecture notes
Course slides will be made available to students prior to each class.

Literature
Course slides will be made available to students.

101-0509-00L Infrastructure Management 1: Process

Abstract
Infrastructure asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods of time. This course provides an overview of the process, from setting goals to developing intervention programs to analyzing the process itself. It consists of weekly lectures and a group project. Additionally, there is a weekly help session.

Objective
There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines are often associated with visual inspections, and much of the research, however, are focused on only part of the large complex problem of infrastructure asset management.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clearer understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will
- understand the main tasks of an infrastructure manager and the complexity of these tasks,
- understand the importance of setting goals and constraints in the management of infrastructure,
- be able to develop and evaluate simple management strategies for individual infrastructure assets,
- be able to develop and evaluate intervention programs that are aligned with their strategies,
- understand the principles of guiding projects and evaluating the success of projects,
- be able to formally model infrastructure management processes, and
- understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.
The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.

2. Positioning infrastructure management in society. As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.

3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.

4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.

5. Help session 1

6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.

7. Determining and justifying monitoring - Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.

8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.

9. Help session 2

10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.

11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.

12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.

13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.

14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

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### Literature

The lecture materials will be distributed via Moodle two days before each lecture.

The lecture materials consist of handouts, the slides, and example calculations in Excel.

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### Prerequisites / notice

Appropriate literature will be handed out when required via Moodle.

This course has no prerequisites.

### Taught competencies

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### Content

<table>
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<tr>
<th>Exercises</th>
<th>Landscape Planning and Environmental Systems (GIS W Exercises)</th>
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<tbody>
<tr>
<td></td>
<td>The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).</td>
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</tbody>
</table>

### Abstract

- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies
- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

### Lecture notes

A script and presentation slides for each exercise will be provided on Moodle.

Will be named in the lecture.
**Prerequisites / notice**

Basic GIS skills are strongly recommended.

### Taught competencies

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**103-0347-00L Landscape Planning and Environmental Systems**

**Abstract**

In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

**Objective**

The aims of this course are:

1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).

2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.

3) To show the importance of ecosystem services.

4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).

5) To identify and measure the characteristics of landscape.

6) Learn how to use spatial data in landscape planning.

**Content**

In this course, the following topics are discussed:

- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

**Lecture notes**

No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

**Prerequisites / notice**

The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

### Taught competencies

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**101-0427-01L Public Transport Design and Operations**

**Abstract**

This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.

Content
Basics for line transport systems and networks Passenger/Supply requirements for line operations Objectives of system and network planning, from different perspectives and users, design dilemmas Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport Planning process, from demand evaluation to line planning to timetables to operations Matching demand and modes Line planning techniques Timetabling principles Allocation of resources Management of operations Measures of realized operations Improvements of existing services

Lecture notes
Lecture slides are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Taught competencies
Subject-specific Competencies | Concepts and Theories | assessed |
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Method-specific Competencies
Analytical Competencies | assessed |
Decision-making | assessed |
Media and Digital Technologies | not assessed |
Problem-solving | assessed |
Project Management | not assessed |

Social Competencies
Communication | assessed |
Cooperation and Teamwork | assessed |
Customer Orientation | assessed |
Leadership and Responsibility | not assessed |
Self-presentation and Social Influence | not assessed |
Sensitivity to Diversity | not assessed |
Negotiation | not assessed |

Personal Competencies
Adaptability and Flexibility | not assessed |
Creative Thinking | assessed |
Critical Thinking | assessed |
Integrity and Work Ethics | not assessed |
Self-awareness and Self-reflection | not assessed |
Self-direction and Self-management | not assessed |

103-0317-00L Spatial Planning and Development W 3 credits 2G D. Kaufmann, A. Kuitenbrouwer
Only for master students, otherwise a special permission by the lecturer is required.

Abstract
The course deals with important theoretical, material and methodical foundations for action and decision-making of spatial relevance. This course discusses central tasks and possible solutions for current and future challenges of spatial development in Switzerland and Europe.
Objective
Spatial development deals with the development, formation and arrangement of our environment. In order to be able to mediate between the different demands, interests and projects of multiple actors, a forward-looking, action-oriented and robust planning is necessary. It is committed - in the sense of a sustainable spatial development - to the economical handling of resources, in particular of the non-replicable resource soil.
The lecture introduces necessary basic knowledge and is based on the following main topics:
– Inward development and challenges of spatial transformation
– Planning approaches and The (political) steering of spatial development
– Interplay of formal and informal processes and processes across different scales of spatial development
– Methods of action-oriented planning in situations of insecurity
– Integrated space and infrastructure development
– Different types of participation in spatial development

By taking up the lecture, the students are able to recognize cross-scale, complex tasks of spatial development and transformation and to use their theoretical, methodical and professional knowledge to clarify them.

Content
- Planning approaches and political organization in Switzerland
- Tasks of spatial relevance
- Key figures and ratios
- Drivers of spatial development
- Steering spatial development I: Policy
- Steering spatial development II: Formal and informal instruments
- Organizing spatial development I: Governance
- Organizing spatial development II: Processes and organization
- Methods in spatial planning I
- Methods in spatial planning II
- Planning in complex situations
- Participation in spatial development
- Present and future core tasks of spatial development

Further information and the documents for the lecture can be found on the homepage of IRL/STL.
The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox ‘Reader’ with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

851-0252-08L Evidence-Based Design: Methods and Tools for Evaluating Architectural Design
Number of participants limited to 40

Particularly suitable for students of D-ARCH

Abstract
Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

Objective
The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

Energy and Mobility

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<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>N. Chokani</td>
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<td>Abstract</td>
<td>The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. These subjects are introduced through a discussion of the basic principles of wind energy generation and conversion, and a detailed description of the broad range of relevant technical, economic and environmental topics.</td>
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<tr>
<td>Content</td>
<td>This mechanical engineering course focuses on the technical aspects of wind turbines; non-technical issues are not within the scope of this technically oriented course. On completion of this course, the student shall be able to conduct the preliminary aerodynamic and structural design of the wind turbine blades. The student shall also be more aware of the broad context of drivetrains, dynamics and control, electrical systems, and meteorology, relevant to all types of wind turbines.</td>
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227-0731-00L Power Market I - Portfolio and Risk Management
W 6 credits 4G D. Reichelt, G. A. Koeppe

Abstract
Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

Objective

Content
1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX
2. Market model
   2.1. Market place and organisation
   2.2. balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions
3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)
4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

Lecture notes
Handouts of the lecture
Prerequisites / notice
1 excursion per semester, 2 case studies, guest speakers for specific topics.
Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636
This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

Prerequisites /

Literature

Course slides will be made available to students prior to each class.

Hand-outs will be distributed. Additional literature and information on the website of the lab:


R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

11. Maximal work and exergy

10. Mixtures

9. Chemical reactions and combustion systems; chemical and phase equilibrium

8. Nonideal gas equation of state and Joule-Thomson effect

7. Refrigeration and heat pump cycles

6. Energy analysis of gas power cycles

5. Energy analysis of steam power cycles

4. Second law of thermodynamics and entropy

3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy

2. Properties of substances: Water, air and ideal gas

1. Thermodynamic systems, states and state variables

Chemical reactions and combustion systems; chemical and phase equilibrium

Lecture notes and supplementary documentation will be available online.

Lecture slides and supplementary documentation will be available online.


This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.
**Taught competencies**

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<td>Media and Digital Technologies</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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**Engine Systems**

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**Abstract**
Introduction to current and future engine systems and their control systems.

**Objective**
Introduction to methods of control and optimization of dynamic systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantitative descriptions.

**Content**
Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.). Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions.

**Lecture notes**
Introduction to Modeling and Control of Internal Combustion Engine Systems
Guzzella Lino, Onder Christopher H.
ISBN: 978-3-642-10774-0

**Prerequisites / notice**
Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups.

**Introduction to Electric Power Transmission: System & Technology**

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<tr>
<td>C. Franck, G. Hug</td>
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**Abstract**
Introduction to theory and technology of electric power transmission systems.

**Objective**
At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of transformers and lines, calculate stationary power flows and other basic parameters in simple power systems.

**Content**
Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems.

**Lecture notes**
Lecture script in English, exercises and sample solutions.

**Battery Integration Engineering**

| W  | 3 credits | 2V+1U |

**Does not take place this semester. Priority given to Electrical and Mechanical Engineering students**

Students are required to have attended one of the following courses:
- 227-0664-00L Technology and Policy of Electrical Energy Storage
- 529-0440-00L Physical Electrochemistry and Electrocatalysis
- 529-0191-01L Renewable Energy Technologies II, Energy Storage and Conversion
- 529-0659-00L Electrochemistry

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*Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2009 of 2345*
Batteries enable sustainable mobility, renewable power integration, various power grid services, and residential energy storage. Linked with low cost PV, Li-ion batteries are positioned to shift the 19th-century centralized power grid into a 21st-century distributed one. As with battery integration, this course combines understanding of electrochemistry, heat & mass transfer, device engineering.

The learning objectives are:

- Apply critical thinking on advancements in battery integration engineering. Assessment reflects this objective and is based on review of a scientific paper, with mark weighting of 10 / 25 / 65 for a proposal / oral presentation / final report, respectively.

- Design battery system concepts for various applications in the modern power system and sustainable mobility, with a deep focus on replacing diesel buses with electric buses combined with charging infrastructure.

- Critically assess progresses in battery integration engineering: from material science of novel battery technologies to battery system design.

- Apply "lessons learned" from the history of batteries to assess progress in battery technology.

- Apply experimental and physical concepts to develop battery models in order to predict lifetime.

- Battery systems for the modern power grid and sustainable mobility.

- Battery lifetime modeling by aging, thermal, and electric sub-models.

- Electrical architecture of battery energy storage systems.

- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.

- Sustainability and life cycle analysis of battery system innovations.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/

  Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning
  https://ias.inf.ethz.ch/teaching/introml-S19

  Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/

  Computational Statistics
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-f18

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The objective of the course is to:
- Provide an overview of viable security practices for operating systems and software applications, focusing on common security mechanisms and their applications.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
The first part of the lecture covers individual system's aspects starting with tamperproof or tamperresistant hardware in general over
operating system related security mechanisms to application software such as host based intrusion detection systems. The main
topics covered are: tamper resistant hardware, CPU support for security, protection mechanisms in the kernel, file system security
(permissions / ACLs / network filesystem issues), IPC Security, mechanisms in more modern OS, such as Capabilities and Zones, Libraries
and Software tools for security assurance, etc.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: patch management,
common software faults (buffer overflows, etc.), writing secure software (design, architecture, QA, testing), compiler-supported security,
language-supported security, logging and auditing (BSM audit, dtrace, ...), cryptographic support, and trustworthy computing (TSG, SGX).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-4640-00L  Network Security  W  8 credits  2V+2U+3A  A. Perrig, S. Frei, M. Legner, K. Paterson

Abstract
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or
as a vehicle to attack end systems.
This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing
protocols, secure DNS systems, and network intrusion-detection systems;
(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
(3) analysis and inference topics such as traffic monitoring and network forensics; and
(4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are
assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L.
Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview
of the most important cryptographic primitives will be provided at the beginning of the course.
The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network
programming language such as C/C++, Go, Python, or Rust.

252-0535-00L  Advanced Machine Learning  W  10 credits  3V+2U+4A  J. M. Buhmann, C. Catrin Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the
classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data
analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics
knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms
and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine
learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Prerequisites / notice**
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

For solving assignments, some programming experience in Python is expected.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

**Objective**

The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactional services, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

**Content**

The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

**Literature**

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

**Prerequisites / notice**

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

**Taught competencies**

Subject-specific Competencies

- Computer Vision
- Natural Language Processing

Concepts and Theories

- assessed
- Concepts and Theories

Techniques and Technologies

- assessed
- Techniques and Technologies

---

**263-5902-00L Computer Vision**

**Objective**

The objectives of this course are:

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Content**

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

**Prerequisites / notice**

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

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**252-3005-00L Natural Language Processing**

**Objective**

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

**Content**

The course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Prerequisites / notice**

Students are expected to have a good understanding of computer vision and image analysis techniques.

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**Life Science and Health**

**Number**

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<thead>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>376-0021-00L Materials and Mechanics in Medicine</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
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<tr>
<td>376-1103-00L Frontiers in Nanotechnology</td>
<td>W</td>
<td>4 credits</td>
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</table>

**Abstract**

- Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Objective**

- Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Content**

- Materials and Mechanics in Medicine: course website on Moodle

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**376-1103-00L Frontiers in Nanotechnology**

**Abstract**

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. They expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

**Objective**

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

**Content**

- Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.
- The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.
- Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.
- Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.
### 376-1714-00L Biocompatible Materials

**Abstract**

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**

The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**

Handouts are deposited online (moodle).

**Literature**


(available online via ETH library)

### 376-0300-00L Translational Science for Health and Medicine

**Abstract**

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

**Objective**

After completing this course, students will be able to understand:
1. What is translational science and what is it not?
2. How to identify need?
3. Disease concepts and consequences for research
4. How to choose the appropriate research type and methodology
5. Ethical considerations including ethics application
6. Pros and cons of different types of research
7. Coordination of complex approaches incl. timing and resources
8. How to measure success?
9. Outcome variables
10. Improving the translational process
11. Challenges of communication?
12. How independent is translational science?
13. Academic boundary conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.

**Lecture notes**

Handouts and references therein.

### 752-6105-00L Epidemiology and Prevention

**Abstract**

The module epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

**Objective**

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

**Content**

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

**Taught competencies**

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### 752-6151-00L Public Health Concepts

**Abstract**

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

**Objective**

At the end of this module students are able:
1. to interpret the results of epidemiological studies
2. to critically assess scientific literature
3. to know the definition, dimensions and determinants of health
4. to plan public health interventions and health promotion projects
5. to draw a bridge from evidence to policies and politics
Concepts and Theories assessed

Introduction to Physical Activity for Health, including sedentary behavior

Critical Thinking

Handouts are provided to students in the classroom.

Stem Cells: Biology and Therapeutic Manipulation

W 4 credits 3G T. Schroeder

Abstract

Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering, and novel technologies relevant for stem cell research and therapy will be discussed.

Objective

Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

Content

We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

Physical Activities and Health

W 3 credits 2V R. Knols, E. de Bruin, further speakers

Abstract

This course introduces/explores the complex relationship between physical activity, sedentary behavior and health. It will discuss the evolution of current physical activity recommendations. It will examine the current evidence base that has informed physical activity recommendations and that identified physical activity as a key modifiable lifestyle behavior contributing to disease and mortality.

Objective

On completion of this course students will be able to demonstrate:

1. knowledge of and critical awareness of the role of physical activity and sedentary behavior in the maintenance of health and the aetiology, prevention and treatment of disease.
2. thorough knowledge and critical awareness of current recommendations for physical activity, and current prevalence and trends of physical activity and associated diseases
3. awareness of current national and international physical activity policies and how these impact on global challenges

Content

Introduction to Physical Activity for Health, including sedentary behavior

Physical activity epidemiology; concepts principles and approaches
Physical activity and all cause morbidity and mortality
Physical activity and chronic disease; Coronary heart disease, diabetes, bone health, cancer and obesity
Physical activity and brain health
Physical activity and sedentary behavior recommendations
Population prevalence of physical activity and sedentary behavior
Physical activity policies
Physical activity assessment

Literature

Core texts for this course are:


Prerequisites / notice

Selective journal articles from relevant journals such as Journal of Physical Activity and Health and Journal of Aging and Physical Activity

Resources and Environment

Lecturers

- A. Brut-Regamey

103-0347-00L Landscape Planning and Environmental Systems

W 3 credits 2V A. Brut-Regamey

Abstract

In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

Objective

The aims of this course are:

1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

The student will be able to describe the natural factors leading to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?
2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biospheres?
3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?
4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?
5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.
Content
Models of individuals
- Deriving single-plant models from inventory measurements
- Plant models based on 'first principles'

Models at the stand scale
- Simple approaches: matrix models
- Competition for light and other resources as central mechanisms
- Individual-based stand models: distance-dependent and distance-independent
- Theoretical models

Models at the landscape scale
- Simple approaches: cellular automata
- Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
- Landscape models

Global models
- Sacrificing local detail to attain global coverage: processes and entities
- Dynamic Global Vegetation Models (DGVMs)
- DGVMs as components of Earth System Models

Lecture notes
Handouts will be available in the course and for download

Literature
Will be indicated at the beginning of the course

Prerequisites / notice
- Ideally basic experiences in modelling and systems analysis
- Basic knowledge of programming, ideally in R
- Good knowledge of general ecology, ideally of vegetation dynamics and forest systems

701-1346-00L Carbon Mitigation W 3 credits 2G N. Gruber
Number of participants limited to 100

Abstract
Future climate change can only be kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

Objective
The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

Content
From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Lecture notes
None

Literature
Will be identified based on the chosen topic.

Prerequisites / notice
Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

103-0347-01L Landscape Planning and Environmental Systems (GIS Exercises) W 3 credits 2U A. Grêt-Regamey, C. Brouillet, M. Galleguillos Torres, N. Klein

Abstract
The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective
- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies

Content
- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes
A script and presentation slides for each exercise will be provided on Moodle.

Literature
Will be named in the lecture.

Prerequisites / notice
Basic GIS skills are strongly recommended.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<td></td>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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#### 701-1253-00L Analysis of Climate and Weather Data

**W 3 credits 2G C. Frei**

**Abstract**
An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.

**Objective**
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.

**Content**
The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

**Lecture notes**
Documentation and supporting material:
- slides used during the lecture
- exercise sets and solutions
- R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

**Literature**
For complementary reading:

**Prerequisites / notice**
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

#### 701-1551-00L Sustainability Assessment

**W 3 credits 2G P. Krüttli, D. Nef**

**Abstract**
The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.

**Objective**
At the end of the course, students:
- know core concepts of sustainable development, main features of social justice in the context of sustainability, a selection of methodologies for the assessment of sustainable development
- have a deepened understanding of the challenges of trade-offs between the different dimensions of sustainable development and their respective impacts on individual and societal decision-making

**Content**
The course is structured as follows:
- overview of rationale, objectives, concepts and origins of sustainable development (approx. 15%)
- overview of the concept of social justice as guiding principle of the social dimension of sustainability (approx. 20%)
- analysis of a selection of concepts and methodologies to assess sustainable development in a variety of contexts (approx. 65%)

**Lecture notes**
Handouts are provided

**Literature**
Selected scientific articles and book-chapters

**Prerequisites / notice**
Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L).
At the end of this course, participants should:

- understand the key physical processes shaping climate change in Europe;
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
- be familiar with relevant observational and modeling data sets;
- be able to tackle simple climate change questions using available data sets.

Contents:
- observational data sets, analysis of climate trends and climate variability in Europe
- global and regional climate modeling
- statistical downscaling
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
- projections of European and Alpine climate change

Prerequisites / notice
Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

751-5201-10L Tropical Cropping Systems, Soils and Livelihoods (with Excursion)

Objective
This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, resilience to soil physics.

Content
On the second module, students gain practical knowledge on field - An integral part of the course is the two-week field project in Kenya, conducting various assessments related to Food and Energy Security.

Prerequisites / notice
We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 23rd 2022, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

Taught competencies
- Global context
- Observational data sets, analysis of climate trends and climate variability in Europe
- Global and regional climate modeling
- Statistical downscaling
- Key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
- Projections of European and Alpine climate change

651-4037-00L Mineral Resources I

Abstract
Principles of hydrothermal ore formation, using base metal deposits (Cu, Pb, Zn) in sedimentary basins to explain the interplay of geological, chemical and physical factors from global scale to sample scale. Introduction to orthomagmatic ore formation (mostly Cr, Ni, PGE); Introduction to supergene residual deposits (Ni, Al)

Can be chosen as an elective course within the Bachelor. Prospective MSc-Students attending the module "Mineral Resources" should attend Mineral Resources I and II in the first year of their MSc studies.

Taught competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Social Competencies
  - Communication
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management
- Social Competencies
  - Cooperation and Teamwork
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

W 3 credits 2G  C. Schär, J. Raczak, S. C. Scherrer

W 5 credits 2G  J. Six, K. Benabderrazik

W 3 credits 2G  C. Chelle-Michou, to be announced
Objective
Understanding the fundamental processes of hydrothermal, magmatic and supergene ore formation, recognising and interpreting mineralised rocks in geological context

Content
(a) Principles of hydrothermal ore formation: base metal deposits in sedimentary basins. Practical classification of sample suites by genetic ore deposit types
Mineral solubility and ore deposition, principles & thermodynamic prediction using activity diagrams. Driving forces and structural focussing of hydrothermal fluid flow
(b) Introduction to orthomagmatic ore formation. Chromite, Ni-Cu sulphides and PGE in layered mafic intrusions. Distribution coefficients between silicate and sulphide melts. Carbonatites and pegmatite deposits.
(c) Introduction to supergene residual deposits with emphasis on Ni laterites and bauxites

Lecture notes
Notes handed out during lectures

Literature
Extensive literature list distributed in course

Prerequisites / notice
2 contact hours per lecture / week including lectures, exercises and practical study of samples, and small literature-based student presentations. Supplementary contact for sample practicals and exercises as required. Credits and mark based on participation in course (exercises, 50%) and 1h30 written exam in the last lecture of the semester (50%).

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies not assessed
Decision-making not assessed

Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>860-0011-00L</td>
<td>Agent-Based Modeling and Social System Simulation - With Coding Project</td>
<td>W</td>
<td>6 credits</td>
<td>2S+2A</td>
<td>N. Antulov-Fantulin, D. Carpentras, D. Helbing</td>
</tr>
</tbody>
</table>

Abstract
This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective
The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

Content
Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lecture notes
The lecture slides will be presented on the course web page after each lecture.

Literature
Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. Students are able to apply their problem-solving and analytical skills to address a particular societal challenge.

Analytical Competencies
- Good programming skills and a good understanding of probability & statistics and calculus are expected.

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Social Competencies: assessed

Transport Planning Methods

W 6 credits 4G K. W. Axhausen

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve/answer planning problems
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

Content
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis. Interim lab sessions take place regularly to guide and support students with the applied part of the course.

Lecture notes
Moodle platform (enrollment needed)

Literature

Case Study Research Paper in Science, Technology and Policy I

W 3 credits 2A Lecturers

Abstract
In the case study research paper, students apply skills and knowledge acquired in the social sciences courses of the ISTP curriculum to address a particular socio-critical challenge.

Objective
Students are able to apply their problem-solving and analytical skills to address a particular societal challenge.

Prerequisites / notice
Good programming skills and a good understanding of probability & statistics and calculus are expected.

Case Study Research Paper in Science, Technology and Policy II

W 3 credits 2A Lecturers

Abstract
In the case study research paper, students apply skills and knowledge acquired in the social sciences courses of the ISTP curriculum to address a particular socio-critical challenge.

Objective
Students are able to apply their problem-solving and analytical skills to address a particular societal challenge.
Based on what they have learned, or are learning, in the companion course, and the skills and knowledge acquired in the social sciences courses of the ISTP curriculum, students identify a particular policy challenge to be addressed. Coached by the instructor of the companion course, or in exceptional cases by another ISTP professor, the develop and implement their research idea, accord-ing to the ISTP guidelines to this end. The result should be a research paper of around 4,000 words (all inclusive, except appendices) that will be graded by the supervisor on the 1–6 scale, based on a grading scheme for this purpose.

Students can enroll in this unit exclusively in combination with another (companion) course to complete the Case Study requirements in the MSc ISTP. The unit allows students to carry out case studies on specific policy issues based on their individual preferences. The companion course should have a policy focus or deal with a policy relevant issue and can be taken either in parallel or prior to the Case Study Research Paper unit. The instructor of the companion course should be able and willing to also serve as the supervisor of the associated case study paper. In the case study research paper, students apply skills and knowledge acquired in the social sciences courses of the ISTP curriculum to address a particular societal challenge.

After successfully completing the companion course and the research paper, the student office will assign both courses to the category case studies.

### Electives

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>351-0778-01L</td>
<td>Discovering Management (Exercises)</td>
<td>W</td>
<td>1</td>
<td>1U</td>
<td>B. Clarysse, L. P. T. Vandeweghe</td>
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<tr>
<td></td>
<td>Complementary exercises for the module Discovering Management.</td>
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<td></td>
<td>Prerequisite: Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This course is offered complementary to the basis course 351-0778-00L, &quot;Discovering Management&quot;. The course offers an additional exercise.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>The general objective of Discovering Management (Exercises) is to complement the course &quot;Discovering Management&quot; with one larger additional exercise.</td>
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<tr>
<td></td>
<td>Content</td>
<td></td>
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<td>Students who are enrolled for “Discovering Management Exercises” are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.</td>
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<tr>
<td></td>
<td>Literature</td>
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<td>All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, &quot;Discovering Management&quot;.</td>
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<tr>
<td></td>
<td>Taught competencies</td>
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<td>Students have the option to either write this alone or in a group of two students.</td>
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<tr>
<td></td>
<td>Subject-specific Competencies</td>
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<td>All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, &quot;Discovering Management&quot;.</td>
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<td>Method-specific Competencies</td>
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<td>Students have the option to either write this alone or in a group of two students.</td>
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<tr>
<td></td>
<td>Social Competencies</td>
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<td></td>
<td>All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, &quot;Discovering Management&quot;.</td>
</tr>
<tr>
<td></td>
<td>Personal Competencies</td>
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<td>Students have the option to either write this alone or in a group of two students.</td>
</tr>
<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
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<td>Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Exercises) 351-0778-01.</td>
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<td></td>
<td>Abstract</td>
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<td>Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship. In particular, the aims of the course are to: (1) broaden understanding of management principles and frameworks (2) advance insights into the sources of corporate and entrepreneurial success (3) develop skills to apply this knowledge to real-life managerial problems The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with. The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts. The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case. The theory sessions will follow a &quot;lecture-style&quot; approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching. Through small group work, you will develop analyses of each of the cases. Each group will also submit a &quot;pitch&quot; with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.</td>
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<tr>
<td></td>
<td>Content</td>
<td></td>
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<td></td>
<td>All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.</td>
</tr>
</tbody>
</table>

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2022 of 2345
Become familiar with the work and challenges of international organizations based in Geneva.

Assessed

Governing the Energy Transition

This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.

Objective
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions
- To gain knowledge on the role of policy and politics in energy transitions

Content
Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary.

This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

Lecture notes
Slides and reading material will be made available via moodle.ethz.ch (only for registered students).

Literature
A reading list will be provided via moodle.ethz.ch at the beginning of the semester.

Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH Phd programmes.

International Organizations (Field Trip)

A two-day field trip to international organizations in Geneva - e.g., the World Trade Organization, the World Health Organization and the International Committee of the Red Cross.

Become familiar with the work and challenges of international organizations based in Geneva.


Prerequisites / notice
Teams of 2-3 students prepare a 2-3 page background reading for the group on a specific international organization and lead the discussion with representatives of that organization during the visit.

International Environmental Politics

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective policies are effective.

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
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Policy Evaluation and Applied Statistics

This course introduces students to key methods for quantitative policy impact evaluation and covers the different stages of the research process. Acquired skills are applied in a self-selected project applying experimental methods. Students also learn how to perform simple statistical analyses with the statistical Software R.
Policy impact evaluation employs a wide variety of research methods, such as statistical analysis of secondary data, surveys or laboratory and field experiments. The course will begin with an overview of the various methodological approaches, including their advantages and disadvantages and the conditions under which their use is appropriate. It will continue with a discussion of the different stages of a policy impact evaluation, including hypothesis generation, formulating a research design, measurement, sampling, data collection and data analysis. For data analysis, linear regression models will be revised, with a focus on difference-in-difference methods, regression discontinuity design and randomized controlled trials used for policy evaluation. Students, who already have a solid background in these methods can skip these sessions.

Throughout the course, students will work on a self-selected project on a suitable topic. In addition, students will have to solve bi-weekly assignments.

701-1631-00L Foundations of Ecosystem Management

Number of participants is limited to 35.

Priority is given to the target groups until 26.09.2022.

Target groups
- MAS ETH in Raumplanung
- MAS ETH in Sustainable Water Resources
- Science, Technology and Policy MSc
- Environmental Sciences MSc
- Agricultural Sciences MSc

Waiting list will be deleted on 30.09.2022.

Abstract
This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

Objective
Students should be able to
a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

Content
Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

Lecture notes
No Script

Literature
Literature

Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future

Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/2020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/686.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective-collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f488e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_fkmr1_1?dchild=1&keywords=coordination+jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Decentralized Collective Learning for Self-managed Sharing Economies
https://dl.acm.org/doi/abs/10.1145/3277668

Further literature will be recommended in the lectures.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<td></td>
<td>Negotiation</td>
<td>not assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

**Number of participants limited to 40.**

### Computational Social Science

851-0585-41L

**W 3 credits 2S**

D. Helbing, J. Argota Sánchez-Vaquero, M. Korecki

**Abstract**

The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g. sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

**Objective**

Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

**Computational Social Science and Global Systems Science** serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.

**Literature**

- Manifesto of Computational Social Science
  - https://link.springer.com/article/10.1140/epjst/e2012-01697-8

- Social Self-Organisation

- How simple rules determine pedestrian behaviour and crowd disasters
  - https://www.pnas.org/content/108/17/6884.short

- Peer review and competition in the Art Exhibition Game
  - https://www.pnas.org/content/113/30/8414.short

- Generalized network dismantling
  - https://www.pnas.org/content/116/14/6554.short

- Computational Social Science: Obstacles and Opportunities
  - https://science.sciencemag.org/content/369/6507/1060?rss%253D1=

- Bit by Bit: Social Research in the Digital Age
  - https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFX22/

Further literature will be recommended in the lectures.
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

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Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

This course is about all that. The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

There will be daily reading assignments, which we will then discuss critically during the class sessions. All of these will be posted in PDF format on a course Moodle. In addition, there will be two books to be read over the course of the semester. Both of these can be accessed from the ETH library or in PDF form free of charge. They are:

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Objective

Taught competencies

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Objective

Taught competencies

Environmental Design Laboratory

Urban Design III

Objective

Taught competencies

Analytical Competencies assessed

Problem-solving not assessed

Negotiation not assessed

Creative Thinking assessed

Critical Thinking assessed

052-0707-00L Urban Design III

W 2 credits

H. Klumpner, M. Fessel

Urban Design III

Objective

How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-
Content

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically react upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

Lecture notes

The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

Literature

860-0026-00L Data Practices

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2S</th>
<th>M. Leese</th>
</tr>
</thead>
</table>

Abstract

The aim of this course is to establish an understanding of data as embedded in social contexts. Studying data from a social scientific perspective is necessary to account for these influences and analyze the ways in which data practices shape the ways in which data allow us to see and modify the world.

Objective

At the end of the term, students will be able to:
- reflect concepts and theories of data practices and situate them within wider social science contexts
- identify key actors, sites, and domain contexts of data practices
- choose appropriate ways and methods to study data practices empirically

Content

The aim of this course is to establish an understanding of data as embedded in social contexts. Data do not exist independently of the ideas, instruments, contexts and rationales used to generate, process, and analyze them. They are not neutral representations of external realities, but they are imbued with political and economic interests, cultural norms and tacit assumptions. Studying data from a social scientific perspective, it is thus necessary to account for these influences and analyze the ways in which data practices shape the ways in which data allow us to see and modify the world.

Lecture notes

Course materials are provided on Moodle.

Prerequisites

The quality of your experience in this course depends on your preparation and active participation. Students will be expected to read the required literature, subject it to critical examination, and discuss it in class.

You will be required to prepare a short preparation assignment for one or two sessions (depending on the overall number of students enrolled in the course), consisting of the preparation of three discussion questions for the session's readings.

Due to the consecutive building blocks that we address throughout the semester, in the best scenario you should not miss any of the sessions. In case you should be unable to attend the seminar, please inform the course organizer by e-mail in advance (mleese@ethz.ch).

851-0589-00L Technology and Innovation for Development

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>P. Aerni</th>
</tr>
</thead>
</table>

Abstract

Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

Objective

- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content

Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies. The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. Technological change illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes

Reader with issue-specific articles. E-version is partly available on Moodle.
The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester. The class will be taught in English. Students will be asked to make a contribution in class choosing one out of three options:

(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

Prerequisites / notice

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in electronic form of an electronic Reader at the beginning of the semester. The class will be taught in English. Students will be asked to make a contribution in class choosing one out of three options:

(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

Literature

Aerni, P. (2021a) 'The ethics of farm animal biotechnology from an anthropological perspective'. Sustainability 13(7), 3674.
Aerni, P. (2021b) 'Decentralized economic ecosystems in Switzerland and their contribution to inclusive and sustainable change'. Sustainability 13(8), 4181
Aerni, P. 2016a. Coping with Migration-Induced Urban Growth: Addressing the Blind Spot of UN Habitat. Sustainability 8(800)


<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0101-86L</td>
<td><strong>Complex Social Systems: Modeling Agents, Learning, W and Games</strong></td>
</tr>
</tbody>
</table>

Number of participants limited to 100.

Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract

This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

Content

Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Lecture notes

The lecture slides will be presented on the course web page after each lecture.

Literature

Social Self-Organization
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187
Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424
The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.
**Prerequisites / notice**

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td></td>
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<tr>
<td>Techniques and Technologies</td>
<td></td>
</tr>
</tbody>
</table>

**Method-specific Competencies**

| Analytical Competencies      | assessed |
| Decision-making              | assessed |
| Media and Digital Technologies| not assessed|
| Problem-solving              | assessed |
| Project Management           | assessed |

**Social Competencies**

| Communication                | assessed |
| Cooperation and Teamwork     | assessed |
| Customer Orientation         | not assessed |
| Leadership and Responsibility| assessed |
| Self-presentation and Social Influence | assessed |
| Sensitivity to Diversity     | assessed |
| Negotiation                  | not assessed |

**Personal Competencies**

| Adaptable and Flexibility    | assessed |
| Creative Thinking            | assessed |
| Critical Thinking            | assessed |
| Integrity and Work Ethics    | assessed |
| Self-awareness and Self-reflection | assessed |
| Self-direction and Self-management | assessed |

Any students enrolling in the course must complete a short writing assignment within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

**Abstract**

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

**Objective**

The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

**Content**

The planned course outline is below

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

**Objective**

1. Understand the causes and consequences of water scarcity and water pollution problems in large international river systems;
2. Understand ways and means of addressing such water challenges;
3. Analyse when and why international efforts in this respect succeed or fail.
Content

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

- 20.Sep Global water challenges
- 27.Sep Nuts and bolts of hydrological modeling and what such models can tell us
- 04.Oct Nuts and bolts of hydrological modeling and what such models can tell us
- 18.Oct Key challenges in international river systems
- 25.Oct Key challenges in international river systems
- 01.Nov Case study 1: Yarmuk
- 08.Nov Case study 2: Mekong
- 15.Nov Case study 3: Colorado
- 22.Nov Case study 4: Nile
- 29.Nov Case study 5: Central Asia
- 06.Dec Wrap up: what we can learn from these case studies
- 13.Dec Exam
- 20.Dec No class

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Lecture notes

Slides and reading materials will be made available via Moodle.

Literature

Slides and reading materials will be made available via Moodle.

The course is open to Master and doctoral students from any area of ETH.

Limited to 40 students.

Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.

151-8101-00L International Engineering: from Hubris to Hope

Abstract

Since Europe surrendered their colonial assets, engineers from rich countries have returned to the African continent to address the real and perceived ills that they felt technology could solve. And yet, 70 years on, the promise of technology has largely failed to deliver widespread, substantive improvements in the quality of life. Why?

Objective

This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.

After completing the course, participants will be able to

- critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world” “developing” “global south” “low and middle-income” and justify their own chosen terminology
- recognize the role of racism and white-supremacy in the development of the Aid industry
- understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
- Debate the merits of international engineering in popular culture and media
- Propose improved SDG indicators that address current shortcomings
- Compare the engineering curricula of different countries to identify relative strengths and shortcomings
- Explain the inherent biases of academic publishing and its impact on engineering failure
- Analyze linkages between the rise of philanthropy and strategic priority areas
- Recommend equitable, just funding models to achieve more sustainable outcomes
- Formulate a vision for the international engineer of the future

Content

Role of international engineering during colonialism

Transition of international engineering following colonialism

White saviourism and racism in international engineering

International engineering in popular culture

The missing role of Engineering Education

Biases academic publishing

The emerging role in Global Philanthropy

The paradox of International funding

Literature


Internship

The performance counts as electives.

Number Title Type ECTS Hours Lecturers
860-0600-00L Internship - Short W 6 credits external organisers

Abstract

The internship is a voluntary part of the MSc curriculum.

Objective

The internship serves to make students familiar with policy analysis in a real world setting, for instance in a government agency, a NGO, a regulatory or public affairs division of a private sector firm, or a consulting firm focused on policy analysis.

Content

The short internship corresponds to a workload of 180 hours, to be accomplished within 3 months.
The internship can be started the earliest in the second semester. The internship needs to be approved by the study director. Therefore students need to hand in a short description to the study secretary before they start the internship.

860-0700-00L  Internship - Long  W  12 credits  external organisers

Abstract  The internship is a voluntary part of the MSc curriculum.
Objective  The internship serves to make students familiar with policy analysis in a real world setting, for instance in a government agency, a regulatory or public affairs division of a private sector firm, or a consulting firm focused on policy analysis.
Content  The long internship corresponds to a workload of 360 hours, to be accomplished within 6 months.
Prerequisites / notice  The internship can be started the earliest in the second semester. The internship needs to be approved by the study director. We ask students to hand in a short description to the study secretary before they start the internship.

Master's Thesis

Number  Title  Type  ECTS  Hours  Lecturers
860-0900-00L  Master's Thesis  O  30 credits  64D  Professors

Abstract  Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Objective  The thesis should demonstrate the students ability to conduct independent research on the basis of the theoreticel and methodological knowledge acquired during the MSc program.

Science, Technology, and Policy Master - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td></td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
<td></td>
</tr>
</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Sport Teaching Diploma

Detailed information on the programme at: www.didaktischeausbildung.ethz.ch

Educational Science

Courses in the category Educational Science are listed under “Programme: Educational Science for Teaching Diploma and TC”.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-15L</td>
<td>Designing Educational Environments in Physical Education (EW2 Sport)</td>
<td>O</td>
<td>4 credits</td>
<td>2S</td>
<td>H. Gubelmann, R. Scharpf</td>
</tr>
</tbody>
</table>

Compulsory course requirements for EW2 Sport: This course is required to be taken prior to EW4 Sport "Outdoor Education: Concepts and Practice" (851-0242-08L).

Abstract
Students learn principles of teaching beyond classroom and regular PE-Lessons:
- Planning and organizing camps and events
- Teaching the "Ergänzungsfach" Sport

As a practical part students design the Outdoor event in EW4 of the following term.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students know how to plan events and camps. To assess curricula critically and to use them properly. How to combine theoretical and practical issues in the ‘Ergänzungsfach’</td>
<td>1. LV Semestreinführung 2. LV Planung Outdoor-Weekend 3. LV Auswertung Outdoor-Event 4. LV Planung Event 5. LV Event-Präsentationen / Schlussveranstaltung</td>
<td>EW2 is compulsory requirement for EW4 Sport</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

This lecture is only apt for students who intend to enrol in the programs “Teaching Diploma” or “Teaching Certificate”. It is about learning in childhood and adolescence.

Abstract
This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
<td>Thematische Schwerpunkte: Lernen als Verhaltensänderung und als Informationsverarbeitung; Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
<td>This lecture is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>C. M. Thurm, T. Braas, P. Edelsbrunner</td>
</tr>
</tbody>
</table>

This course can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)".

Abstract
Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand research methods used in the empirical educational sciences. Understand and critically examine information from scientific journals and media. Understand pedagogically relevant findings from the empirical educational sciences.</td>
<td></td>
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</tbody>
</table>

Subject Didactics in Sport

Important: You can only enroll in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0315-00L</td>
<td>Sports Didactics I</td>
<td>O</td>
<td>4 credits</td>
<td>2V</td>
<td>A. Thoma</td>
</tr>
</tbody>
</table>

Only for Teaching Diploma Sports.

Simultaneous enrolment in Introductory Internship Sports - course 557-0210-00L - is compulsory.

Abstract
Practical implementation in sports of general didactics, with the planning, implementation and evaluation of topics from all the sports-specific areas of tuition in secondary school Level II.
Supervisors

Title
Implementation of practical sport into general teacher training with planning, execution and evaluation of the topics from all sport-specific areas of the education at this level in Section II.

Type
- try out different teaching structures, such as the lesson, teaching unit, block periods and extra units in sport in addition to those on the timetable.

Implementation of practical sport into general teacher training with planning, execution and evaluation of the topics from all sport-specific areas of the education at this level in Section II.

Lecture notes
Skript unter: https://moodle-app2.let.ethz.ch/course/view.php?id=117>

Literature
Kernlernmittel Jugend und Sport Lehrdplom-Studierende müssen die Fachdidaktik Sport I zusammen mit dem Einführungspraktikum Sport - LE 557-0210-00 - belegen.

Prerequisites / notice

<table>
<thead>
<tr>
<th>557-0203-01L</th>
<th>Mentored Work Subject Didactics Sport</th>
<th>O</th>
<th>4 credits</th>
<th>9A</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>The students:</td>
<td></td>
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<tr>
<td></td>
<td>- Implement the objectives of general didactics in respect of the different types of sport at school.</td>
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<tr>
<td></td>
<td>- master the planning, implementation and evaluation of topics from all the sports-specific areas of tuition.</td>
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<tr>
<td></td>
<td>- gain an overview of the preparation necessary for the different requirements placed on a sports teacher at secondary school Level II.</td>
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<tr>
<td></td>
<td>- try out different teaching structures, such as the lesson, teaching unit, block periods and extra units in sport in addition to those on the timetable.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Implementation of practical sport into general teacher training with planning, execution and evaluation of the topics from all sport-specific areas of the education at this level in Section II.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Lehrdiplom-Studierende müssen die Fachdidaktik Sport I zusammen mit dem Einführungspraktikum Sport - LE 557-0210-00 - belegen.</td>
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</tbody>
</table>

**Professional Training in Sport**

**Important:** You can only enroll in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0210-00L</td>
<td>Introductory Internship Sports</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>A. Thoma, further lecturers</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>During the introductory teaching practice, the students sit in on 3 lessons given by the teacher responsible for their teaching practice, and teach 7 lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.</td>
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</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Students observe 3 and teach 7 lessons, supervised by experienced teachers.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>see moodle 00 - Lehrdplom Sport</td>
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<tr>
<td></td>
<td>Disler P. Dida-Methodische Modelle in der Ausbildung, Dissertation in 2004, 152</td>
<td></td>
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<tr>
<td></td>
<td>Loosch E., Allgemeine Bewegungslerei, Limpert Verlag Wiesbaden 1999</td>
<td></td>
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<tr>
<td></td>
<td>Roth K. &amp; K. Willemezick, Bewegungswissenschaft, Rowohlt Verlag Reinbek 1999</td>
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<tr>
<td></td>
<td>Röthig P. Sportwissenschaftliches Lexikon, Schorndorf Verlag 2003</td>
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<td></td>
<td>Röthig P. &amp; a. Grössing (Hrsg.) Bewegungslerei, Kursbuch 3, Wiesbaden 1990/3</td>
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</tbody>
</table>

| 557-0208-00L   | Teaching Internship Sports                | O    | 8    | 17P   | A. Thoma, further lecturers |
| **Objective**  | Students apply their theoretical background in practice. By teaching sports lessons they improve their teaching skills and classroom management and learn how to interact with pupils. Together with their supervisor they develop an ability of critical reflection of their tasks. | | | | |
| **Abstract**   | The teaching practice takes in 50 sessions. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice. | | | | |
| **Content**    | Students use their disciplinary skills and educational knowledge for teaching. They know how to judge topics of their subject and can present them in class. Teaching and classroom management in practice is the main target of this course; students have to find a balance between instruction and self-determined activity of their pupils. Together with their supervisors they learn to assess their tasks and achievements. | | | | |
| **Lecture notes** | see moodle 00 - Lehrdplom Sport | | | | |
Students apply teaching methods they learned in Didactics I and II in practical lessons in the gym hall. They also supervise their fellow students and give feedback.

Together with their supervisor they develop an ability of critical reflection of their tasks.

They know how to judge topics of their subject and can present them in class.

- 2 ECTS Examination Lessons
- 4 ECTS Specialized Courses with Educational Focus
- 3 ECTS Educational Science
- 3 ECTS Didactics

Only for BSc HST and Teaching Diploma Sports.

Simultaneous enrolment in “Examination Lesson II Sports” (557-0211-02L) is compulsory.

In the context of an examination lesson conducted and graded at a high school, the candidates need to prove their subject-matter-based and didactic skills they have acquired in the course of their training.

Simultaneous enrolment in "Examination Lesson I Sports" (557-0211-01L) is compulsory.

In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of their subject-matter-based and didactic skills they have acquired in the course of their training.

The teaching practice takes in 30 Sessions. It lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Students use their disciplinary skills and educational knowledge for teaching.

- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

The candidates show that they are in a position to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

The candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

The course will only take place with 12 or more registrations.

BSc HST students with a J+5-Coach certificate can take the course from 3rd semester onwards, others from 5th semester onwards, 3rd semester students, please send a copy of your J+5-Coach certificate to the study administration HST (hst@hest.ethz.ch).

The candidates need to prove their subject-matter-based and didactic skills they have acquired in the course of their training.

Students use their disciplinary skills and educational knowledge for teaching.

Teaching and classroom management in practice is the main target of this course; students have to find a balance between instruction and self-determined activity of their pupils.

Together with their supervisor they develop an ability of critical reflection of their tasks.

Prerequisites for the Teaching Internship: all ECTS in Teaching Diploma Sports, apart from:

- 3 ECTS Educational Science
- 4 ECTS Specialized Courses with Educational Focus
- 2 ECTS Examination Lessons

#### Specialized Courses in Respectious Subject with Educational Focus I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1033-00L</td>
<td>History of Sports</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Gisler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Comprehension for development and changes of sports from the ancient world to the presence. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day.</td>
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<tr>
<td>Objective</td>
<td>Understanding for the development and adaptation of sports from the ancient world to present times.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Ein Skript für die aktuelle Veranstaltung wird abgegeben.</td>
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</table>

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1107-00L</td>
<td>Sport Pedagogy</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>C. Herrmann</td>
</tr>
<tr>
<td>Abstract</td>
<td>The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on &quot;pedagogical-psychological aspects of competence development in the context of a multi-perspective physical education&quot;.</td>
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<tr>
<td>Objective</td>
<td>Development of pedagogical-psychological competences for the optimisation of future teaching activities.</td>
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</tr>
</tbody>
</table>
| Content      | - Subject area of educational psychology  
- Motivating students in physical education  
- Building self-efficacy and strengthen the self-concept  
- Promoting positive emotions and a positive attitude to anxiety  
- Encouraging self-directed learning  
- Leading classes and promoting cooperation  
- Communicating with students efficiently  
- Reflecting your own expectations critically  
- Handling gender issues sensitively  
- Promoting inclusion / Strengthening social and moral development  
- Dealing with difficult students  
- Evaluating achievements of students |
| Lecture notes| Teaching materials for the individual lectures are provided to the students via moodle. |

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1117-00L</td>
<td>Sport Psychology</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>H. Gubelmann, C. Baldasarre Ackermann, P. Müller</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students' expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.</td>
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</tbody>
</table>
| Content      | Main Topics  
- Introduction to sport psychology  
- Cognitions in sports: mental rehearsal and mental training  
- Emotions and stress  
- Motivation: goal-setting in sports  
- Career and career transition in elite sport  
- Coach-Athlete-Interaction  
- Psychological aspects of sport-injury rehabilitation  
- Group dynamics in sport |
| Lecture notes| Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle. |

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1127-00L</td>
<td>Sociology of Sport</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>R. Bürgi</td>
</tr>
<tr>
<td>Abstract</td>
<td>These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.</td>
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</tbody>
</table>
| Objective    | The lectures set out to:  
- present the different dimensions, functions and interrelationships of present-day sport  
- provide an introduction to the central theories and models of (sport) sociology  
- show how far sport reflects society and how it changes and becomes more differentiated in the process  
- take current examples to highlight the sociological view of sport. |
Content
- Sport and social change: developments and trends
- The economy and the media: dependencies, consequences, scandals
- Social inequalities and distinctions: gender differences and group behavior
- Conflicts and politics: sports organizations, doping, violence

Lecture notes Literature
Selected materials for the lecture are available on the Moodle platform.

A detailed program with additional references will be delivered at the beginning of the lecture.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

557-0205-00L Mentored Work Specialised Courses in the Respective O Subject with an Educational Focus Sport A

Only for Teaching Diploma Sports.

Abstract
Pedagogical application of research projects for schools
Introduction of sports pedagogical oriented research projects. Competency to a youth friendly movement and sports education. Competent 'pedagogical application' of research projects in the field of movement and sport. Feed in of scientific findings to school lesson settings.

Objective
The students combine and apply general educational aims with a general and specific background of research projects.
They know different educational concepts of the above mentioned, recognise its strengths and weaknesses and are able to apply concepts appropriate to the situation.
They are interested in the (thought-) processes of education and research in sports in Switzerland.
They use their knowledge of research matters to guide educational thought-processes.
They are interested in processes of research in sports.
They approach the research interest of their pupils with the knowledge of sports psychology, sports sociology, sports pedagogy, and sports history.

Content
Die Studierenden wenden die Bewegungs- und Lernziele des Sportunterrichts aus den kantonalen Lehrplänen im Unterricht an und können diese begründen.
Sie interessieren sich für die Prozesse der Forschung im Sport
Sie erlernen anhand von Projektaufgaben die didaktische Anwendung der Sportsziologie, Sportsziologie, Sportpädagogik und Sportgeschichte und ziehen daraus Konsequenzen für den situativ-variabel orientierten Unterricht.
Sie setzen ihr Wissenswissen ein, um bei den Lernenden Denkprozessen anzustoßen und zu begleiten.

Lecture notes Literature
Skript unter: https://moodle-app2.let.ethz.ch/course/view.php?id=117>

Prerequisites / notice
Auswahl von 2 aus 4 Angeboten:
a) Motor-Learning im Sport (Fachbereich Sportpsychologie)
   - Vorlesung
   - Praktische Umsetzung von Forschungsprojekten für die Schule
b) Sport im Spannungsfeld zwischen Ethik und Kommerz (Fachbereich Sportsoziologie)
   - Vorlesung
   - Praktische Umsetzung von Forschungsprojekten für die Schule
c) Mehrperspektivität im Sportunterricht (Fachbereich Sportpädagogik)
   - Vorlesung
   - Praktische Umsetzung von Forschungsprojekten für die Schule
d) Historische Entwicklung der Lehr und Lernmodelle im Sportunterricht (Fachbereich Sportgeschichte)
   - Vorlesung
   - Praktische Umsetzung von Forschungsprojekten für die Schule

Alle Wahlfachangebote beinhalten:
- Sportwissenschaftliche Fachpraxis
- Praktische Umsetzung der Erkenntnisse für die Schule

Specialized Courses in Respective Subject with Educational Focus II

At least 6 CP's must be obtained in this category.
Further courses must be chosen from the "Sports Practice: In-depth Education".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>557-0206-00L</td>
<td>Mentored Work Specialised Courses in the Respective O Subject with an Educational Focus Sport B</td>
<td>Only for Teaching Diploma Sports.</td>
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</tbody>
</table>

Abstract
Refurbishment of research projects dealing with motor competencies in sport and professional scientific content related to this area. Competent "didactical implementation" of research content. The Fachwissenschaftliche Vertiefung II orientates itself to the guiding principles of cognitive, conditional and coordination aspects of movement.

Objective
Connection of sport and human movement science and educational instruction.

Content
Scientific analysis of sports disciplines in order to improve instruction

Lecture notes
Skript unter: https://moodle-app2.let.ethz.ch/course/view.php?id=117>
see specific subjects

Prerequisites / notice
Mentorated paper in selected sports disciplines.

see Sport Teaching Diploma, Sport Practical: Major Education

Compulsory Elective Courses

At least 6 CP's must be acquired in this category.
Further courses must be chosen from the "Sports Practice: In-depth Education and Specialized Education".

see Sport Teaching Diploma, Sport Practical: Major Education
The Teaching Diploma in Sports will only be granted to students holding a Master, Diploma or Licentiate degree in Human Movement Sciences and Sports or Health Sciences and Technology. Additionally, a Sports Practice encompassing 56 CPs is required. The Sports Practice can be partly conducted during the Bachelor and Master programmes in Sports.

### Assessments

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0101-00L</td>
<td>Assessment Polysports</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>M. Altermatt</td>
</tr>
</tbody>
</table>

Abstract
Successful completion of the course “Assessment Polysports” is requirement for access to further practical sport courses. Basic skills in ball games, athletics, gymnastics, fitness, and dance are repeated and tested.

Lecture notes
During the semester the documents are steadily available electronically.

### Basic Education

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>557-0412-01L</td>
<td>Dance I</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>C. König</td>
</tr>
</tbody>
</table>

Abstract
Compulsory for Teaching Diploma Sports!
Dance and movement comprise of expression, strength, endurance, suppleness, flexibility, rhythmic movement sequences, coordination and dance cant with music - combined with creativity. Implementation of these aspects.

Objective
- To arouse and stimulate the interest for dancing
- To enjoy dancing without prior knowledge and to experience the possibilities within dance from easy to hard
- To gain insight into different dance styles
- To improve one's own dance technique in framework of the topics offered: To acquire and expand personal skills and knowledge
- To expand the diversity and repertoire of movements
- To improve coordination with the help of music
- To understand music and to be able to interpret the music’s character

Content
- Kennenlernen von verschiedenen Tanzstil: HipHop/Streetdance, Jazz, Jive (RNR), Salsa...
- Grundlagen von Techniken einzelner Tanzstil kennenlernen und verbessern
- Erarbeiten von Tanzkombinationen
- Der Tanz und die Bewegung beinhalten Ausdruck, Kraft, Ausdauer, Geschmeidigkeit, Flexibilität, rhythmische Bewegungsabläufe, Koordination und Tanzphasen mit Musik- gepaart mit Kreativität und Lebensfreude

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>557-0433-00L</td>
<td>Apparatus Gymnastics and Trampoline</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>M.-M. Jäggi</td>
</tr>
</tbody>
</table>

Abstract
Compulsory for Teaching Diploma Sports!
To get to know and understand the basics of movement (core movements) and its respective actions and functions on apparatuses, on the floor and in acrobatics as well as to create individual and cooperative combinations according to qualitative criteria.

Objective
The students should be able to:
- acquire and consolidate apparatus related core movements as well as apply and create such combinations
- utilize their own strength as well as the resulting impact in a differentiate way in order to precisely move the swinging, flying, falling and twisting body
- gain orientation safety and room orientation while twisting and flying
- gain sensitivity for social competences (e.g. to assist, to observe) within a small group.

Content
- structural relationships within rotations (turnarounds, handsprings and free somersaults)
- core poses as motor basic training
- variety of position modifications in handstands
- core movements and combinations on parallel bars, high bar, floor and in swinging rings
- different forms of vaulting as well as springing in movements like handstands and somersaults

Literature
- Trampolinschule nach der Part-Methode, BASPO 2013

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>557-0503-01L</td>
<td>Basketball</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>C. Ferrari</td>
</tr>
</tbody>
</table>

Abstract
Compulsory for Teaching Diploma Sports!
Basketball-Basics:
Basic technical skills: dribbling/ballhandling, passing, shooting, footwork and defense related to the specific Basketball rules.
Tactical skills: 1 on 1, give & go, hand-off, pick & roll, pick & pop and the application of these skills in a game 3 on 3 on one basket.
Objective
The students know the technical basic Basketball elements (dribbling, changes of hand, stops, starts, footwork, pass, shot, defense), they can demonstrate them and use them correctly in a game situation 3 on 3 on one basket. The students know the tactical Basketball elements (1 on 1, give & go, hand-off, pick & roll, pick & pop) and can apply these skills in a game 3 on 3 on one basket. The students know the main rules of the game.

Content
Learning the basic elements in drills and games, learning (pre-)tactical elements (1-1, getting open, 2-2, backdoor cut, frontdoor cut, 3-3, give & go, hand-off, pick & roll, pick & pop, spacing) and assemble them into systems, that can be used in a game 3 on 3 on one basket.

Lecture notes
available on Moodle

Literature


manual for monitors of the Swiss Youth & Sports program (available through the "Jugend & Sport" office, german / french / italian)

Chervet, Michel: Baskebkball. Fundamental skills for offensive play. Video (german / french), Magglingen, BASPO, 2003 (CHF 34.-). Order at video@baspo.admin.ch

Taught competencies
Subject-specific Competencies
Concepts and Theories not assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking not assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Abstract
Acquisition/consolidation basic skills for soccer.
Support and development the individual conditions/talent/skill and introduction of basic methods will be treated.

Objective
Acquisition/consolidation basic skills in soccer
Support and development the individual conditions/talent/skill and introduction of basic methods want to be at the centre of attention.

Content
Technique:
Dribble, short passport play, get the ball under control, shot,
Individual tactics:
offensive/defensive 1vs1; keep ball in own rows
various contests in support of different techniques and tactics

Literature
- Bucher, Walter (Hrsg.) 1020 Spiel- und Übungsformen im Kinderfussball, 7. unveränderte Auflage 2011, Hofmann-Verlag, Schorndorf

Prerequisites / notice
1. Prerequisites:
Small being able in soccer.
Readiness to train.
2. After this course you can get the licence "manager for children".
Prerequisites: Only 1 absence from the lessons "football for children", the book "Kinderfussball" can be bought in the course

557-0514-03L  Soccer I  W  2 credits  2G  H. A. Russheim, P. C. Humbel

Prerequisites: Assessment III (BSc HST) or Assessment Polysports passed.
Compulsory for Teaching Diploma Sports!

557-0533-01L  Floorball I  W  2 credits  2G  F. Ungrad

Prerequisites: Assessment III (BSc HST) or Assessment Polysports passed.
Compulsory for Teaching Diploma Sports!

Abstract
Experiencing Unihockey/Floorball as an indoor sportsgame
Learning by doing to improve personal sport skills and widening personal abilities in ball sports
Learning by practising/playing and linking that knowledge to theories of motor learning

Objective
Practising unihockey to improve personal sport skills and widening personal abilities in ball sports
Improvement of personal unihockey-skills
Learning by practising/playing and linking that knowledge with theories of motor learning

Prerequisites / notice
1. Prerequisites:
Small being able in soccer.
Readiness to train.
2. After this course you can get the licence "manager for children".
Prerequisites: Only 1 absence from the lessons "football for children", the book "Kinderfussball" can be bought in the course
Transfer of ideas into motor movements and motor skills.
Personal improvement by practising different motor skills as moving the ball/ballcontrol, passing, shooting.
Training of personal sports abilities in ballgames.
Analysis of play-situations and corresponding motor movement.
Understanding, learning and applying the rules of the game.
Practical test of skills and in game activities at the end of the semester.

Classes are based on insights from the book "unihockey basics" by B. Beutler, M. Wolf.
ISBN 3-03700-043-0

Please bring your personal hockey stick with you to class.
Fitness II

Prerequisites: completion of basic education in Fitness I. Compulsory for Teaching Diploma Sports.

Abstract
Acquisition of further skills and deepened knowledge in the areas of fitness coaching and group fitness.

Objective
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Deepened understanding of the factors that determine human performance and fitness. Acquisition of personal and methodological skills in the area of fitness coaching and group fitness.

Content
- Anamnese und Trainingsplanung
- Trainingsmittel im Fitnessbereich
- Methoden im Kraft und Ausdauerbereich
- Einführung von Personen an Fitnessgeräten, Instruktion und Korrektur
- Funktionelle Anatomiekenntnisse im Fitnessbereich
- Sicherheits- und Trainingsregeln im Group Fitness
- verbales & visuelles Cueing
- Funktionsles Training im Group Fitness
- Training der Tiefenmuskulatur ohne/mit instabiler Unterlage
- Intervaltraining als Stundenformat
- Koordinationstraining ohne/mit Hilfsmittel
- Dehnmethoden
- Zielgruppenangepasste Stundenformate

Lecture notes
Wird im Unterricht abgegeben oder auf Moodle bereitgestellt

Literature
- Skript und Unterlagen Fitness I
- Training fundiert erklärt, J. Hegner, 5. Auflage 2012

Prerequisites / notice
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Gymnastics / Acrobatics II

Prerequisite:
Completion of the basic courses
- "Apparatus Gymnastics and Trampoline I" (557-0433-00L); and
- "Acrobatics I" (557-0432-01L).

Abstract
Acquirement and Application of classic as well as modern forms of movement on different apparatuses and on the trampoline
Application and Creation of established basic skills

Objective
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

The students should be able to:
- enhance their repertoire on apparatus specific movements
- deepen their existing store of movements
- improve their individual performance competencies
- realize and comprehend transfer characteristics within the movement learning process
- work up methodically and didactically a chosen skill
- gain sensitivity for social competences (e.g. to assist, to observe, to advise) within a small group
- compose and present to music within a group of three a creative performance

Content
- further core movements und its combinations on different apparatuses
- handsprings and (free) somersaults back- and forwards, respectively twists back- and forwards on different apparatuses
- creative and cooperative composition in a threesome accompanied by music
- vault springs and touching down springs (stuetz springs) to overcome obstacles in an artful way (Freerunning)
- integrated theoretical coherences of the qualitative movement learning process
- conveyance of methodical and didactical principles as well as topic specific criteria
- functional warm-up with regard to specific contents

Badminton / Volleyball II

Prerequisite:
Completion of the basic courses
- "Badminton I" (557-0601-00L); and
- "Volleyball I" (557-0542-01L).

Abstract
In this course you will build up and experience different tactical and technical exercise forms for classes. At the same time you will be able to deepen your own skills.

Volleyball:
Identify and experience the main aspects of teaching volleyball and adapt it for your own lessons using didactical and methodical concepts. Improve individual technical and tactical skills in volleyball.

Objective
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Badminton:
To build methodical and didactical concepts to teach badminton classes.
To deepen your own technical and tactical abilities.

Volleyball:
You identify and experience the main aspects of teaching volleyball and adapt it for your own lessons using didactical and methodical concepts.
You improve your individual technical and tactical skills in volleyball.
Content

Badminton:
In this course we work on possibilities to build up different tactical and technical exercise forms and structures for classes. You get to know a variety of games. You learn how you can diversify exercises – depending on the level and the age of your pupils.

Volleyball:
You experience and discuss the main problems of teaching volleyball in school. You learn in practice how to deal with it and work out your own solutions. You improve your individual technical and tactical skills in diverse games and practice drills.

Lecture notes
Published during the semester on "moodle".

Education Acquired Outside ETH

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<tr>
<th>Number</th>
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<th>Type</th>
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<td>Diploma Sports!</td>
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<td>provides you with skills to supervise groups in</td>
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<td>- To recognize danger in, on and around water</td>
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<td>- Knowledge and handling of life saving equipment</td>
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<td>- Rescue and towing techniques</td>
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<td>- Orientation under water</td>
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<td>- To rescue a person</td>
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<td>- Basis knowledge in anatomy and first aid</td>
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<td>related to safety and hygiene measures in case of</td>
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<td>injuries and acute illnesses.</td>
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<td>- To be able to judge an injured person and to</td>
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<td>- To list the characteristics of a sprain, strain,</td>
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<td>dislocation and to apply first-aid interventions</td>
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<td>- To carry out bandages with common material</td>
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<td>- To explain the function of the cardiovascular system</td>
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<td>- To name the symptoms of poisoning</td>
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<td>- To list the signs of acute illness</td>
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<td>- To put together the content of a first-aid box</td>
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<td>- To carry out safety interventions in daily situations.</td>
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<td>557-0452-00L</td>
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<td>Youth Sports&quot; in the course of &quot;Magglinger Hochschulwochen&quot;.</td>
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<td><strong>Objective</strong></td>
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<td>- to experience and reflect on qualitatively good</td>
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<td>sports using practical examples.</td>
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<td>- to get to know the institution BASPO/EHSM with its</td>
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<td>tasks and network.</td>
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<td>- to gain proficiency as a J+S Coach in school and</td>
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<td>youth sports.</td>
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Compensation Courses

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<tr>
<td>557-0603-01L</td>
<td>Snowsports I - Ski</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>C. Elmiger-Schnyder, further</td>
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<td>Prerequisites: Assessment I+II (BSc HST) or Assessment Polysports passed.</td>
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<td>100% presence is required!</td>
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Registration via Study Administration necessary.
Compulsory for Teaching Diploma Sports!

Abstract
Education in the disciplines of winter sports.
- J+S Education possibility
- Transfer Offpist
- Transfer Nordic Cross

Objective
The students:
- To experience the different winter sports.
- To gain an understanding of how to ski off-piste.
- Transfer: Input Nordic Cross!

Content
- To apply and vary personal technique of alpine skiing
- To acquire and vary personal technique of cross-country skiing

Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain Nordic Cross

557-0603-02L Snowsports I - Snowboard W 2 credits 2G C. Elmiger-Schnyder, further lecturers
Prerequisites: Assessment I+II (BSc HST) or Assessment Polysports passed.
100% presence required!

Abstract
Education in the disciplines of winter sports.
- J+S Education possibility
- Transfer Offpist
- Transfer Nordic Cross

Objective
The students:
- To experience the different winter sports!
- To gain an understanding of how to ski off-piste!
- To gain an understanding of how to Nordic Cross.

Content
- To apply and vary personal technique of snowboarding
- To acquire and vary personal technique of cross-country skiing

Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain an understanding in how to Nordic Cross

557-0605-01L Snowsports II - Ski W 2 credits 2G C. Elmiger-Schnyder, further lecturers
Prerequisite: Basic course Snowsports I - Ski passed.
100% presence is required!

Abstract
Education in the disciplines of winter sports.
- J+S Education possibility
- Transfer Offpist
- Transfer Nordic Cross

Objective
The students:
- To experience the different winter sports!
- To gain an understanding of how to ski off-piste!
- To gain an understanding of how to Nordic Cross.

Content
- To apply and vary personal technique of snowboarding
- To acquire and vary personal technique of cross-country skiing

Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain an understanding in how to Nordic Cross

Prerequisites / notice
Requirement: Basic course in Snowsport I completed.

557-0605-02L Snowsports II - Snowboard W 2 credits 2G C. Elmiger-Schnyder, further lecturers
Prerequisite: Basic course Snowsports I - Snowboard passed.
100% presence is required!

Abstract
Education in the disciplines of winter sports.
- J+S Education possibility
- Transfer Offpist
- Transfer Nordic Cross

Objective
The students:
- To experience the different winter sports!
- To gain an understanding of how to ski off-piste!
- To gain an understanding of how to Nordic Cross.

Content
- To apply and vary personal technique of snowboarding
- To acquire and vary personal technique of cross-country skiing

Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain an understanding in how to Nordic Cross

Prerequisites / notice
Requirement: Basic course in Snowsport I completed.

557-0605-03L Snowsports II - Telemark W 2 credits 2G C. Elmiger-Schnyder, further lecturers
Prerequisite: Basic course Snowsports I (Ski or Snowboard) passed.
100% presence is required!

Abstract
Education in the disciplines of winter sports.
- J+S Education possibility
- Transfer Offpist
- Transfer Nordic Cross

Objective
The students:
- To experience the different winter sports!
- To gain an understanding of how to ski off-piste!
- To gain an understanding of how to Nordic Cross.

Content
- To apply and vary personal technique of snowboarding
- To acquire and vary personal technique of cross-country skiing

Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain an understanding in how to Nordic Cross

Prerequisites / notice
Requirement: Basic course in Snowsport I completed.
### Additional Requirements in Sports Science

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Taylor, R. List</td>
<td>Requirement: Basic course in Snowsport I completed.</td>
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<td>376-0207-00L</td>
<td>Exercise Physiology</td>
<td>W</td>
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<td>C. Spengler, F. Gabe Beltrami, R. M. Rossi</td>
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<td>376-1033-00L</td>
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<td>2V</td>
<td>M. Gisler</td>
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<td>376-1107-00L</td>
<td>Sport Pedagogy</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>C. Herrmann</td>
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**Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.**

**Abstract**

Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports.

**Objective**

Off-piste education:
- Planning and realization of back-country skiing
- Handling of the environment
- Avalanche prophylaxis

**Content**

Off-piste education:
- Planning and realization of back-country skiing
- Handling of the environment
- Avalanche prophylaxis

**Prerequisites / notice**

Requirement: Basic course in Snowsport I completed.
Content
- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

Lecture notes
Teaching materials for the individual lectures are provided to the students via moodle.

Literature

376-1117-00L
Sport Psychology

Table: 
<table>
<thead>
<tr>
<th>W</th>
<th>2 credits</th>
<th>2V</th>
<th>H. Gubelmann</th>
</tr>
</thead>
</table>

Abstract
This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.

Objective
Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students' expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.

Content
Main Topics
- Introduction to sport psychology
- Cognitions in sports: mental rehearsal and mental training
- Emotions and stress
- Motivation: goal-setting in sports
- Career and career transition in elite sport
- Coach-Athlete-Interaction
- Psychological aspects of sport-injury rehabilitation
- Group dynamics in sport

Lecture notes
Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle.

Literature

376-1127-00L
Sociology of Sport

Table: 
| W | 2 credits | 2V | R. Bürgi |

Abstract
These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.

Objective
The lectures set out to:
- present the different dimensions, functions and interrelationships of present-day sport
- provide an introduction to the central theories and models of (sport) sociology
- show how far sport reflects society and how it changes and becomes more differentiated in the process
- take current examples to highlight the sociological view of sport.

Content
Sport and social change: developments and trends
The economy and the media: dependencies, consequences, scandals
Social inequalities and distinctions: gender differences and group behavior
Conflicts and politics: sports organizations, doping, violence

Lecture notes
Selected materials for the lecture are available on the Moodle platform.

Literature

376-0130-00L
Laboratory Course in Exercise Physiology

Table: 
| W | 4 credits | 4P | C. Spengler |

Abstract
HST: Possible from the 5th semester on.

Objective
Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

Content
Laboratory course:
Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test), dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.

Lecture notes
Tutorial on Laboratory Experiments in Exercise Physiology
(Editor: Exercise Physiology Lab)

Literature
- Schmidt/Lang/Heckmann: Physiologie des Menschen, Springer-Verlag, Heidelberg
- Kenney/Wilmore/Costill: Physiology of Sport and Exercise, Human Kinetics
Prerequisites / notice
Prerequisite:
Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)
Desirable:
Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)

376-2019-00L Applied Movement Analysis W 2 credits 2G P. Schütz, to be announced

Abstract
Based on examples from sports science, practical training and movement therapy, different methods of movement analysis are applied and compared.

Objective
Students are able to assess human movements using various methods of movement analysis. They learn to systematically analyse movements by structured observation and to apply scientific methods according to the situation.
They use modern technology as well as their own perception and experience.

Content
During the lecture students get acquainted with different scientific and practical methods of functional and biomechanical movement analysis.
Based on concrete examples, these methods will be applied and compared. The examples range from sport, everyday movement to therapy, such as ball sports, gymnastics/acrobatics, gait/running and strength training.
In the first phase of the lecture, the different approaches are presented and applied. In the process, current technical devices will be used.
In a second phase, individual projects are worked out in small teams. The projects will be discussed, presented and graded.

Lecture notes
Class material will be distributed using the moodle platform.

Sport Teaching Diploma - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>O</th>
<th>Compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td></td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td></td>
<td>Eligible for credits</td>
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<tr>
<td>Z</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>V</th>
<th>lecture</th>
</tr>
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<tbody>
<tr>
<td>G</td>
<td></td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td></td>
<td>exercise</td>
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<td>S</td>
<td></td>
<td>seminar</td>
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<td>K</td>
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<td>colloquium</td>
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<tr>
<td>P</td>
<td></td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td></td>
<td>independent project</td>
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<td>D</td>
<td></td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td></td>
<td>revision course / private study</td>
</tr>
</tbody>
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ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
**Principles of Political Science**

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0577-00L</td>
<td>Principles of Political Science</td>
<td>O</td>
<td>4 credits</td>
<td>2+1U</td>
<td>T. Bernauer</td>
</tr>
</tbody>
</table>

**Abstract**

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

**Objective**

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

**Content**


**Leistungskontrollen**

a) Erster Test (...)
b) Zweiter Test (...)

Ergeben gemittelt das Ergebnis der benoteten Semesterleistung

**Kreditpunkte**

4 ECTS-Punkte (Zeltaufwand insgesamt ca. 120 Arbeitsstunden)

**Lecture notes**


Pro Kurseinheit (Woche) sind ca. 30–40 Seiten zu lesen. Für einzelne Kurseinheiten müssen Sie etwas mehr lesen (zwei Buchkapitel, ca. 60-80 Seiten insgesamt). Es lohnt sich also, bereits von Anfang des Kurses an ein wenig «auf Vorrat» zu lesen.

Weitere Lehrmaterialen finden Sie auf: http://www.ib.ethz.ch/teaching/pwgrundlagen

Sie müssen die zugewiesenen Buchkapitel vor der jeweiligen Kurseinheit gründlich lesen und Fragen notieren, damit wir effizient vorankommen. Pro Kurseinheit (Woche) sind ca. 30–40 Seiten zu lesen. Für einzelne Kurseinheiten müssen Sie etwas mehr lesen (zwei Buchkapitel, ca. 60–80 Seiten insgesamt). Es lohnt sich also, bereits von Anfang des Kurses an ein wenig «auf Vorrat» zu lesen.

Tutorat: Im Tutorat wird das aus der Lektüre der Buchkapitel sowie der Vorlesung mitgebrachte Wissen weiter vertieft, u.a. anhand von möglichen Testfragen. Eine regelmässige und engagierte Teilnahme am Tutorat, die gründliche Lektüre der Buchkapitel und die Teilnahme an der Vorlesung stellen sicher, dass Sie bei den Tests keine «Überraschungen» erleben werden.


Bei einer Gesamtnote (auf 0.25 gerundeter Mittelwert der beiden Tests) ≥ 4.0 gilt der Kurs als bestanden und es werden vier ECTS Punkte zugeteilt. Ausnahme: Im BA Staatswissenschaften werden die vier ECTS Punkte erst nach erfolgreichem Absolvieren der Basisprüfung zugeteilt.

Für die Studierenden des BA Staatswissenschaften ist der Inhalt dieses Kurses Prüfungsstoff für die Hälfte der Basisprüfung im Fach Politikwissenschaft, die von Prof. Bernauer durchgeführt wird (die zweite Hälfte der Basisprüfung führt Prof. Schimmelfennig durch). Das Absolvieren der beiden Tests während des Semesters ist für Studierende des BA Staatswissenschaften freiwillig, aber stark empfohlen. Für jeden der beiden Tests erhalten Sie bei einer Note von 4 oder mehr einen Bonus für die Basisprüfung im Fach Politikwissenschaft. Sie können sich also durch das Absolvieren der beiden Tests in der Basisprüfung verbessern bzw. ein Polster erwerben.

Prüfungsstoff ist der gesamte Inhalt der Vorlesung und des Tutorats. Für diesen Kurs ist keine zusätzliche (separate) Prüfungsanmeldung nötig, die Anmeldung für den Kurs in mystudies deckt alles ab.

Für die beiden Tests dürfen Sie vier Seiten Notizen benutzen (zwei Blätter beidseitig beschrieben). Bitte beachten Sie, dass die Notizblätter handgeschrieben beschrieben sein müssen. Elektronisch bedruckte Notizblätter werden ausnahmslos nicht zur Prüfung zugelassen.

WENN Sie gerne mehr über sozialwissenschaftliche Konzepte und Forschungsmethoden lernen möchten, sind diese beiden Bücher ausserordentlich gut:

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### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>351-1034-00L</td>
<td>Microeconomics</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>A. Fetz, M. Gysler</td>
</tr>
</tbody>
</table>

*Not for students belonging to D-MTEC!*

Abstract

Introduction to the economic decisions of households and firms, and their coordination through markets. Analysis of different market structures and of situations in which markets may lead to socially undesirable outcomes.

Objective

Understanding of basic microeconomic models. Ability to apply these models to real world economic situations.

Content

Economics as a science, division of labour and welfare (concept of comparative advantage), supply and demand (market equilibrium, elasticity), households (preferences, demand), firms (technology, cost analysis, profit maximisation, supply), perfect competition, monopoly and oligopoly, externalities, public goods, information, factor markets and income distribution via email

Literature


Prerequisites / notice

Course macroeconomics in the spring term
The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and...
Objective
1) Understanding the goal and the basic procedures of (empirical social sciences) scientific work (philosophy of science, theory building, research design, as well as the correct employment of sources, data and literature).
2) Identification of relevant research questions.
3) Creating a common basis for a thorough and systematic analysis of these.

Content
Political Methodology I seeks to introduce students to the basics of scientific work and procedures in the social sciences, which in turn shall allow them - also in conjunction with Political Methodology II - to conduct work that fulfills satisfactory standards of research quality throughout their further studies.
With regard to Political Methodology I, this seminar primarily focuses on the philosophy and theory of (empirical social) sciences, its structure, and procedures. The seminar emphasizes substantive contents and ways of presenting them, research and, conceptual work. Additionally, it deals with the basis of establishing research designs with politically relevant questions and hypotheses.

Literature

Prerequisites / notice
Each student will be graded by two exercises (50% each).

1) Source analysis and acquisition: based upon a research question that will be given by the lecturer, the student shall collect a comprehensive list of the relevant literature and summarize that with her/his own words.
2) Critical analysis of sources: based upon a research article that the student chooses on her/his own, the student shall write a critical analysis of that, which mirrors frame and structure of scientific writing.

Submission dates will be communicated in the first meeting.

Languages
First Foreign Language

3. Semester
Remaining Core Courses of the Bachelor Programme
By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations.

Introduction to research on political violence in domestic and international politics. This course covers the causes and solutions to different types of political violence including interstate wars, civil wars, terrorism or social protests.

Objective
Knowledge on different types of political violence and their causes.

Content
This course offers an introduction to research on political violence in domestic and international politics. First, we discuss the definitions and concepts used in conflict research, the data and methods commonly applied and their historical development. Second, we focus on interstate wars and examine in this context state formation, nationalism and democracy. The third part of the course focuses on different types of political violence, including civil war, terrorism or social protests.

Prerequisites / notice
The course «Conflict Research II» in the following semester further examines civil wars.

Exercises complete the lectures, where the literature will be further discussed. The participants write a short memo (max. 3 pages) about one of the required readings.

853-0047-00L World Politics Since 1945: The History of International Relations

Abstract
This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.

Objective
By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.

Content

Literature

853-0065-00L Business Administration I

Abstract
The course BA I provides an understanding of the principles of General Business Management. It comprises an introduction to the basic business principles within a business acumen with a clear focus on value creation. The theory conveyed is illustrated with exercises, case studies and examples from business practice.

Objective
Objectives
- Understanding and application of instruments and methods of general management.
- Driving customer equity.
- Reflection of common business practices.

Content
I ENTERPRENEURIAL THINKING AND ACTION
1. Customer orientation and value creation
2. Business and Environment
3. Legal forms of business under Swiss corporate law

II BUSINESS PROCESSES
4. Marketing I
5. Marketing II

III SUPPORTING PROCESSES
6. Human Resource Management I
7. Human Resource Management II

IV MANAGEMENT PROCESSES
8. Organisation
9. Value-based management
10. Mission, Business Norms and Business Culture
11. Strategic Management

Literature

853-0063-00L Military History I

Abstract
The lecture outlines the development of the armed forces (assets regarding manpower, technology and armament), the concepts of warfare and the actual warfare in the 19th and 20th century.

Objective
- Distinguish between military history as a subject and historiography as a way of describing events;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Based on the approach regarding revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Exemplify the issues regarding the evolution of the combat (First and Second World War, Vietnam War and Algerian War).

Content
The lecture first examines the bases of the science of (military) history. It focuses on how military history developed from war history, on specific similarities and differences between military history and general historiography, the different ways of dealing with history in Switzerland, Germany, France and in the Anglo-Saxon cultural area (different approaches) as well as on institutions which deal with military history such as universities, military academies, national and international commissions and associations etc.

The lecture is structured along the lines of the concept of "Military Revolution" and starts with the formation of modern, European armed forces after the Oranian Army reform in the 17th century.

Based on the "Military Revolution" approach, the lecture examines the structural changes regarding the armed forces and the development of warfare from the 18th to the 20th century. Special emphasis will be put on how the battlefield was revolutionized due to the Napoleonic wars, the industrialization in the 19th century, the First World War, the mechanization and totalization during the Second World War and the period of the Cold War.

Literature

853-0082-00L Strategic Studies I

Abstract
The lecture series treats high-impact strategic theory from antiquity to the present.
Objective

The participants know how the understanding of strategy has evolved over time. They understand the interplay of strategy's basic components: ends, ways, means. They know the most important classics of strategy and war theory, especially against their specific historical background. Based on the analysis of historical and contemporary examples, they are aware of the mismatch between declaration and implementation of any given strategy. They are capable of analyzing original texts and modern scholarly works in the field of strategic studies.

Content

The two-semester course series treats classic texts of strategic studies from antiquity to the present. Term 1 covers the theories up to roughly 1900, term 2 treats the theories eversince. Theories are considered classic if they were prominent in their respective times and if they enjoyed a strong reception thereafter, be it in literature, in academic debates or as guidelines for action (doctrine). Each out of some 50 theories is discussed in three steps: historical context, core elements and reception.

Lecture notes

Prior to the lectures, the respective slides are provided as well as primary sources and literature, as preparatory readings (via Moodle). The program is also available online (www.mlak.ch).

Literature

Peter Paret, Makers of Modern Strategy. From Machiavelli to the Nuclear Age, Princeton 1986.


ISBN 978-3-658-25287-8

Recommended literature, in academic debates or as guidelines for action (doctrine). Each out of some 50 theories is discussed in three steps: historical context, core elements and reception.

853-0302-00L European Integration

Only for Public Policy BA.

Objective

The seminar is designed to help students understand the European Union as a particular kind of political system that differs both from the nation-state and from other international organizations. It imparts basic knowledge on the development, institutions, procedures, and policies of the EU and provides an introduction to major approaches to integration theory and political science research on the EU.

Content

1. Introduction
2. Theories of European integration
3. Institutional development of European integration
4. Development of political integration
5. Internal market and monetary union
6. Internal and external security policies
7. Constitutionalization
8. Widening and differentiation
9. European integration in crisis
10. Institutions
11. Law-making and law enforcement
12. Statehood and democracy
13. Switzerland, the EEA and Neighbourhood Policies

Lecture notes

Schimmelenning, Frank: Europäische Integration (erhältlich zu Beginn des Kurses)

Literature

Lecture notes

Die Leistungskontrolle findet durch eine Seminarpräsentation und einen schriftlichen Schlusstest statt.

853-0101-02LL Defense Economics I

In terms of structure and content, the event follows the lecturer's book "Militärökonomie" (Military Economics), which is available in two language versions:

- German language: ISBN 978-3-658-06146-3

Objective

* Recognizing parallels and contrasts between business and military thinking;
* Recognize and analyze planned economic systems;
* Understand the link between institutions, human action and economic results.

Content

The contents correspond to sections 1 to 2.2.5 of the above book. The following will be discussed:

1. fundamental military economic problems including historical introduction to the topic
2. the institutional foundations of a military organisation
3. the modern military as a planned economy system
4. actors and stakeholders in the system

Lecture notes

Lecture slides are given to the participants before the first lecture. In addition, the above mentioned book will be handed over to the participants. Participants of the lecture who are not professional officer candidates are requested to obtain the book from the library or bookstore.

Literature

ISBN 978-3-658-06146-3

ISBN 978-3-658-25287-8
### Languages

#### First Foreign Language

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0416-00L</td>
<td>English, Part III</td>
<td>O</td>
<td>3 credits</td>
<td>4G</td>
<td>S. Schweizer</td>
</tr>
</tbody>
</table>

**Abstract**
The knowledge and skills acquired in the second semester serve as a basis for further improvements in the areas of speaking, listening, reading and writing, which will enable students to enroll for the Cambridge exams. The goal is to reach Council of Europe (CEFR) level C1 or C2 depending on the linguistic proficiency of the students.

**Objective**
This three-semester English course should enable the participants to successfully use the English language in an international military setting.

**Content**
- Read, analyze and write military and civilian documents
- Listening comprehension using current radio or TV reports
- Practise speaking with group discussions and short presentations
- Systematic revision and extension of key grammar points
- Systematic acquisition of general and military vocabulary

### 5. Semester

#### Remaining Core Courses of the Bachelor's Programme

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0049-00L</td>
<td>Introduction to Constitutional Law in Security Policy</td>
<td>O</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Müller</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture deals with questions of competence and the security policy instruments in the federal state, conveys the basic principles of police law and deals with the management of extraordinary situations. Special topics are the army, civil protection, the intelligence service, the legal status of army members, private security providers and cooperation (at home and abroad).

**Objective**
The students can:
- explain the basic concepts of security law;
- outline the basic constitutional order for Swiss security policy, identify the competences of the Confederation and assess the advantages and disadvantages of this basic order;
- explain and evaluate special legal forms of action;
- distinguish the tasks of security policy actors and assess forms of cooperation;
- derive legal limitations for operations of the armed forces from the Federal Constitution;
- identify the basic principles and individual special aspects of military-civilian cooperation;
- identify the police powers of the armed forces and determine the permissibility of using forms of coercion;
- describe the legal status of members of the armed forces and explain the special responsibility of officers;
- establish the relationship between the actions of state actors and the guarantee of fundamental rights;
- assess current challenges in security law.

**Content**
The lecture consists of three parts: Basics, Security policy instruments, Consolidation.

- In the first part, terms of security and police law are introduced, the Swiss security constitution (Confederation and cantons) is explained and the significance of fundamental rights guarantees is shown.

- In the second part, the security policy instruments of the Confederation and the cantons are assessed critically. A special focus is placed on the army. In addition to its constitutional anchoring and its tasks, the forms of deployment enshrined in the relevant regulations (e.g. military act) are examined from a legal perspective. Special attention is given to police powers of military forces.

- The third part of the course deals in greater depth with the intelligence service, civil protection, the legal permitted tasks of private security providers and the legal status of military personnel.

**Lecture notes**
The last hour before the examination is reserved for revision and questions.

**Reader**
https://moodle-app2.let.ethz.ch/course/view.php?id=11049

**Literature**
The basic source of the lectures is (purchase recommended):
- Gianfranco Albertini/Thomas Armbruster/Beat Spörri, Militärisches Einsatzrecht, Zürich 2016 (ISBN 978-3-7255-7080-5; around CHF 89.-)

Other texts are prepared in a reader.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0303-00L</td>
<td>Swiss Foreign Policy</td>
<td>O</td>
<td>3 credits</td>
<td>2V</td>
<td>D. Möckli</td>
</tr>
</tbody>
</table>

**Abstract**
This course analyzes the foundations and challenges of Swiss foreign policy. After reviewing the history of foreign policy conceptions since the early 20th century, we will discuss the determining factors of Swiss foreign policy and examine, together with guest speakers from the foreign ministry, current international developments and respective foreign policy challenges.

**Objective**
Students should acquire a sound understanding of Swiss foreign policy and the relevant academic and political debates associated with it.

**Content**


**Lecture notes**
Students will receive a handout of slides accompanying the lectures.

**Literature**
The required reading will be listed at the beginning of the semester.

**Prerequisites / notice**
The course will be supported by an e-learning environment.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>853-0321-00L</td>
<td>Advanced Course II (Seminar)</td>
<td>O</td>
<td>4 credits</td>
<td>3S</td>
<td>A. Wenger, S. De Rosa, T. Ferst, T. Szwircsnes Tresch</td>
</tr>
</tbody>
</table>

**Abstract**
This two-semester course is divided into several groups. A core question relating to the topic of the seminar paper is being developed (I), which will be chosen in coordination and under the guidance of the respective lecturers. Upon conclusion, the paper will be presented in class (II). Based on the qualifications obtained in the Proseminar, a high academic standard is expected.

**Objective**
Based on the research design prepared in part I of the seminar, candidates write a comprehensive academic term paper. The term paper should be considered as a good preparation for the BA thesis.
Seminar II builds on the findings of seminar I. Within the broader framework of the overall theme of the seminar (Foreign Policies and Security Strategies of the Great Powers) and based on the approved research design of seminar I, participants write their term paper (in close consultation with the lecturer).

A Reader was provided as part of seminar I (cf. online platform Moodle).

cf. Reader and Reading List Seminar I

**853-0061-00L**

**Introduction to Cybersecurity Politics**  
**O  3 credits  2G**  
M. Dunn Cavelty, F. J. Egloff

**Abstract**  
The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

**Objective**  
Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.

**Content**  
We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

**Lecture notes**  
A script with background information and comments on the literature will be made available at the beginning of the semester.

**Literature**  
Literature for each session will be available on Moodle.

The lecture is being supported by a website on Moodle.

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
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</tr>
<tr>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
</tr>
<tr>
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</tr>
<tr>
<td>Problem-solving</td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td>Self-direction and Self-management</td>
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<tr>
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<td></td>
<td></td>
<td>not assessed</td>
</tr>
</tbody>
</table>

**853-0046-00L**

**Social Psychology of Groups**  
**O  3 credits  2V**  
T. Heilmann

**Abstract**  
Basic social psychological topics are elaborated, presented, and discussed in the most application-oriented way.

**Objective**  
You are able to recognize and explain various social psychological aspects and factors and to evaluate them in your everyday decisions in terms of planning, content and operations. This means you will be able to assess when various social psychological aspects may play a role in your everyday work. And you are able to assess what this may subsequently mean for your work or leadership processes.

**Content**  

1) Führungspychologie: Kurzer Einblick in neuere Führungstheorien.
2) Destructive Führung: Was sollten wir nicht machen?
3) Soziale Kognition: Warum und auf Basis welcher wenigen Informationen wir sehr schnell Urteile über Personen treffen.
4) Soziale Wahrnehmung/Attribution: Wie erklären wir uns, dass sich jemand im Alltag in bewusster Art und Weise verhält?
5) Diversity & Frauen & Führung: Woran kann es liegen, dass weibliche Führungskräfte besondere Herausforderungen bei der Ausübung von Führung haben?
6) Sozialer Einfluss: Welche Normen erleben Sie beim Militär? Und wie leiten diese Erwartungen unser Verhalten im Berufssalltag?
7) Gruppenspsychologie: Was heisst "Gruppe"? Wie entwickeln sich (militärische) Gruppen, z.B. in der RS? Welche Prozesse können zwischen Gruppen geschehen?
9) Überzeugungsstrategien
Literature


Prerequisites / notice

Languages

Second Foreign Language

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
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<td>853-0402-00L</td>
<td>German, Part II</td>
<td>W</td>
<td>3</td>
<td>4G</td>
<td>S. Schweizer</td>
</tr>
</tbody>
</table>

Abstract

Based on the knowledge and skills acquired during the first semester, speaking and discussion skills related to military situations are examined and put into practice. Attention is focused on issues such as instruction, qualification and career interviews.

Objective

This two-semester German course should enable the French and Italian speaking participants to fulfil their function as professional officers also in the German language.

Content

- Read, analyse and write military and civilian documents
- Listening comprehension using current radio or TV reports
- Practise speaking with group discussions and short presentations
- Systematic revision and extension of key grammar points
- Systematic acquisition of general and military vocabulary

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0404-00L</td>
<td>French, Part II</td>
<td>W</td>
<td>3</td>
<td>4G</td>
<td>S. Schweizer</td>
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</tbody>
</table>

Abstract

Based on the knowledge and skills acquired during the first semester, speaking and discussion skills related to military situations are examined and put into practice. Attention is focused on issues such as instruction, qualification and career interviews.

Objective

This two-semester French course should enable the German speaking participants to fulfil their function as professional officers also in the French language.

Content

- Read, analyse and write military and civilian documents
- Listening comprehension using current radio or TV reports
- Practise speaking with group discussions and short presentations
- Systematic revision and extension of key grammar points
- Systematic acquisition of general and military vocabulary

Bachelor’s Colloquium and Bachelor’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>853-0315-00L</td>
<td>BA Colloquium</td>
<td>O</td>
<td>2</td>
<td>2K</td>
<td>F. Schimmelfennig</td>
</tr>
</tbody>
</table>

Abstract

The BA Colloquium prepares students for their BA thesis with regard to content, administration, and methodology. During the colloquium, students choose a topic and a supervisor for their thesis. The skills students have acquired during the course of their studies are also enhanced and optimized.

Objective

The students are being prepared administratively and methodologically to write their BA-thesis after completing the course.

Content

The BA Colloquium prepares students for their BA thesis with regard to content, administration, and methodology. During the colloquium, each student has to choose a topic for his/her BA-thesis. The students also choose their supervisors, whereas the goal is an even distribution of the supervisors. Finally, the methodological competences which were acquired during the first four semesters will be complemented.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2056 of 2345
Bachelor's Thesis (O) - 10 credits - 8D

Abstract: The Bachelor Thesis completes the Bachelor program and consists of a scientific project carried out independently under the tutorship of an ETH or MILAK lecturer in Public Policy.

Objective: The elaboration of the Bachelor Thesis should further students' capacities to work independently, structured and scientifically.

---

**Electives**

**Recommended Elective Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>853-0654-00L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>10</td>
<td>8D</td>
<td>Lecturers</td>
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</table>

**Abstract:**

The Bachelor Thesis completes the Bachelor program and consists of a scientific project carried out independently under the tutorship of an ETH or MILAK lecturer in Public Policy.

**Objective:**

The elaboration of the Bachelor Thesis should further students' capacities to work independently, structured and scientifically.

---

**Additional Elective Courses**

These Electives may be chosen from the start of the Bachelor Study Programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>853-8002-00L</td>
<td>The Role of Technology in National and International Security Policy</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>A. Wenger, A. Dossi, M. Leese, O. Thülert</td>
</tr>
</tbody>
</table>

**Abstract:**

The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

**Objective:**

Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

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**Prerequisites / notice**

The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos, oliver.roos@sipo.gess.ethz.ch.
Content

Main Topics
- Introduction to sport psychology
- Cognitions in sports: mental rehearsal and mental training
- Emotions and stress
- Motivation: goal-setting in sports
- Career and career transition in elite sport
- Coach-Athlete-Interaction
- Psychological aspects of sport-injury rehabilitation
- Group dynamics in sport

Lecture notes

Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle.

Literature


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376-1127-00L  Sociology of Sport

Abstract

These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.

Objective

The lectures set out to:
- present the different dimensions, functions and interrelationships of present-day sport
- provide an introduction to the central theories and models of (sport) sociology
- show how far sport reflects society and how it changes and becomes more differentiated in the process
- take current examples to highlight the sociological view of sport.

Content

Sport and social change: developments and trends
The economy and the media: dependencies, consequences, scandals
Social inequalities and distinctions: gender differences and group behavior
Conflicts and politics: sports organizations, doping, violence

Lecture notes

Selected materials for the lecture are available on the Moodle platform.

Literature


A detailed program with additional references will be delivered at the beginning of the lecture.

---

851-0589-00L  Technology and Innovation for Development

Abstract

Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

Objective

- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content

Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies.

The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes

Reader with issue-specific articles. E-version is partly available on Moodle.
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Prerequisites / notice

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester. The class will be taught in English. Students will be asked to make a contribution in class choosing one out of three options:

(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

860-0023-00L International Environmental Politics W 3 credits 2V T. Bernauer
Particularly suitable for students of D-ITET, D-USYS

Visibility, Sustainability will be a prerequisite for participation. The course will be open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Reading materials and slides will be available via Moodle.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

363-0341-00L Introduction to Management W 3 credits 2G Z. Zagorac-Uremovic, D. Baschung, J. O'Neil

This course is an introduction to the critical management skills involved in planning, organizing, leading and controlling an organization.
Objective

By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate routine operations in order to meet evolving customers' and societal needs. The students will achieve these goals by being able to:
- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how change, internally or externally initiated, impact such relationships.

Content

This course is an introduction to critical management skills involved in planning, organizing, leading and controlling an organization. This course follows a "systemic" view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations: Input (i.e., from external environment), strategy, people, work, formal and informal structure of the organization, and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements together by means of real-life cases, whereby the focus will be on the critical reflection of particular cases of fits and misfits between those elements and on the application of a selection of tools and methods.

Lecture notes

The content of the course will rely on different readings, cases and selected chapters of following book:

Literature

The content of the course will rely on different readings and on selected chapters of following book:

Prerequisites / notice

Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on moodle. This preparation is required to participate in the lectures.

The final exam is requested for all types of students (BSc, MSc, MA, PhD, and Exchange students).

It is not possible to retake the exam within the same term or academic year.

We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
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<tr>
<td></td>
<td>Problem-solving</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>Customer Orientation</td>
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<tr>
<td>Personal Competencies</td>
<td>Leadership and Responsibility</td>
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<td></td>
<td>Adaptable and Flexibility</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
</tr>
</tbody>
</table>

851-0735-10L  Law for Entrepreneurs  W  2 credits  2V  P. Peyrot

Abstract

Particularly suitable for students of D-ITET, D-MAV

Objective

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the legal aspects involved in setting up and managing an enterprise.

Lecture notes

A comprehensive script will be made available online on the moodle platform.

101-0515-00L  Project Management  W  2 credits  2G  C. G. C. Marx

Abstract

The course gives a detailed introduction of various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

Objective

Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company wide success.

- They shall work with project management concepts.
- They shall be familiar with the issues of project management, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.

Lecture notes

No. The lecture slides and other additional material will be available for download from Moodle a week before each class.

701-0703-00L  Environmental Ethics  W  2 credits  2V  A. Deplazes Zemp

Abstract

The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective

On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

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### Lecture notes

Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

### Literature

- John O'Neill et al.: Environmental Values, 2006

General introductions:

### Prerequisites / notice

The procedure for accumulating CP will be explained at the start of term.

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>Lecturer</th>
<th>Credits</th>
<th>ECTS</th>
<th>Language</th>
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<td>151-0757-00L</td>
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<tr>
<td>851-0180-00L</td>
<td>Research Ethics</td>
<td>G. Achermann, P. Emch</td>
<td>2</td>
<td>2G</td>
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### 151-0757-00L Environmental Management

**Abstract**

An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

**Objective**

Overview on environmental management and environmental management systems, general methods and principles.

**Content**

- Introduction to environmental management / environmental management systems, energy and material flows; economical and ecological problems in industry; characterisation of an enterprise (incl. management handbook); structure and contents of an environmental management system; overview on the ISO 14001 ff. series; methods for environmental evaluation and assessment; integrated management systems; planning methodology and life-cycle-design; planning example

**Lecture notes**

Information about environmental management and environmental management systems will be provided by a CD or mail.

**Literature**

A list with literatures and links will be provided.

**Prerequisites / notice**

Delivery of a case study, worked out in groups. Language: Teaching in English on request.

### 851-0180-00L Research Ethics

**Abstract**

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

**Objective**

- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

**Number of participants limited to 40**

**Particularly suitable for students of D-BIOL, D-CHAB, D-HEST**

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I. Introduction to Moral Reasoning

1. Ethics - the basics
2. Normative Ethics
3. Decision making: How to solve a moral dilemma

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
2. Social responsibility
3. Dual use research

III. Research Ethics – External responsibilities

1. Research involving human subjects
2. Data Management

Lecture notes

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice

What are the requirements?

First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):

1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) and you are expected to attend all classes. You are responsible for your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Taught competencies

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Method-specific Competencies

- Communication
- Cooperation and Teamwork

Social Competencies

- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

Personal Competencies

851-0861-01L Arabic I A1.1

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract

Arabic I leads to A1.1 level on the Common European Framework of Reference for Languages. Arabic I is the first part (A1.1 level) of a four-semester Arabic course. The goal of the course is for participants to acquire basic language skills in speaking, listening comprehension, and the reading and writing of Arabic script.

Objective

Participants are able to use the Arabic language adequately in selected areas. The focus is on speaking; reading and listening comprehension at A1.1 level on the Common European Framework of Reference for Languages; learning Arabic script; and the development of cultural competence. The following content areas are embedded in various communicative tasks: Greeting each other, introducing yourself and speaking about yourself (personal and professional identity, place of residence), making simple phone calls, requesting information, and making appointments.

W 2 credits 3G University lecturers
### Public Policy Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
<th>W</th>
<th>Eligible for credits</th>
</tr>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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### Key for Hours

<table>
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<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

**ECTS**

- **European Credit Transfer and Accumulation System**

- Special students and auditors need special permission from the lecturers.
Core Courses

Statistical Modelling

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>Statistical Modelling</td>
<td>W</td>
<td>8</td>
<td>4G</td>
<td>P. L. Bühlmann</td>
</tr>
</tbody>
</table>

Abstract
In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

Objective
Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

Content

Prerequisites / notice
This is the course unit with former course title "Regression".

Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

Time Series Analysis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-4623-00L</td>
<td>Time Series Analysis</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Meinshausen</td>
</tr>
</tbody>
</table>

Abstract
The course offers an introduction into analyzing time series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

Prerequisites / notice
Basic knowledge in probability and statistics

Applied Statistics

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power

Prerequisites / notice

Mathematical Statistics

The two core courses Fundamentals of Mathematical Statistics (401-3621-00L) and Likelihood Inference (401-8623-00L) are similar in content. Therefore only one of them can be recognised towards the Master's degree in the core course area «Mathematical Statistics».

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3621-00L</td>
<td>Fundamentals of Mathematical Statistics</td>
<td>W</td>
<td>10</td>
<td>4V+1U</td>
<td>S. van de Geer</td>
</tr>
</tbody>
</table>

Abstract
The course covers the basics of inferential statistics.

Likelihood Inference (University of Zurich)

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-8623-00L</td>
<td>Likelihood Inference (University of Zurich)</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>University lecturers</td>
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</table>

Abstract
Overview over the basics of likelihood inference.

Subject Specific Electives

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3601-00L</td>
<td>Probability Theory</td>
<td>W</td>
<td>10</td>
<td>4V+1U</td>
<td>W. Werner</td>
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</tbody>
</table>

At most one of the three course units (Bachelor Core
**401-3627-00L High-Dimensional Statistics**

**Abstract**

"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

**Objective**

Knowledge of methods and basic theory for high-dimensional statistical inference

**Content**

Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and 1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

**Literature**


**Prerequisites / notice**

Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

**401-3610-00L Stochastic Simulation**

**Abstract**

This course provides an introduction to stochastic Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

**Objective**

Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

**Content**


**Lecture notes**

A script will be available in English.

**Literature**


Prerequisites / notice

Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

**401-4633-00L Data Analytics in Organisations and Business**

**Abstract**

This lecture covers organizations and businesses' end-to-end data analytics process and deepens each process stage. It shows why a stage is needed and what actions are taken in each stage. It gives steps successfully applied in practice and loopholes when issues arise. Case studies from various industries will be presented for each stage.

**Objective**

This course aims to give the students an understanding of the whole data analytics life cycle in the business world. It shows the expectations of companies and how it is measured. It enables the student to manage successfully all the non-methodological aspects of a data analytics project which are the primary source of failure in end-to-end executions. The student will become familiar with the "business language, and cultural aspects of organizations. It also gives an overview of the data analytics tool, platform, and methods ecosystem for successfully technical data analyses.
The lecture's presentation slides will be provided. 

**Sampling Surveys**

The students will learn about methods of kernel smoothing and application of concepts to data. The aim will be to build sufficient interest in

1. **An Introduction to R.** http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Starting with an overview of selected results from parametric inference, kernel smoothing will be introduced along with some asymptotic theory, optimal bandwidth selection, data driven algorithms and some special topics. Selected numerical examples will be used for motivation. The presented methods will also be applicable elsewhere.

The students will learn about methods of kernel smoothing and application of concepts to data. The aim will be to build sufficient interest in the topic and intuition as well as the ability to implement the methods to various different datasets.

**Part II of the course builds on part I and covers the following additional topics:**

- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options
- Extending basic R: packages

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=15522

### References:

- **Statistical Inference,** by S.D. Silvey, Chapman & Hall.
- **Regression Analysis: Theory, Methods and Applications,** by A. Sen and M. Srivastava, Springer.
- **Density Estimation,** by B.W. Silverman, Chapman and Hall.
- **Nonparametric Simple Regression,** by J. Fox, Sage Publications.
- **Applied Smoothing Techniques for Data Analysis:** the Kernel Approach With S-Plus Illustrations, by A.W. Bowman, A. Azzalini, Oxford University Press.

### Additional references will be given out in the lectures.

### Prerequisites:

A background in Linear Algebra, Calculus, Probability & Statistical Inference including Estimation and Testing.
Abstract | The elements of a sample survey are explained. The most important classical sample designs (simple random sampling and stratified random sampling) with their estimation procedures and the use of auxiliary information including the Horvitz-Thompson estimator are introduced. Data preparation, non-response and its treatment, variance estimation and analysis of survey data is discussed.

Objective | Knowledge of the Elements and the process of a sample survey. Understanding of the paradigm of random samples. Knowledge of simple random sampling and stratified random sampling and capability to apply the corresponding methods. Knowledge of further methods of sampling and estimation as well as data preparation and analysis.

Content | Topics that will be discussed are:

- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys priors), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)

Lecture notes | A script will be available in English.


Prerequisites / notice | Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

### Mathematics of Data Science

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<tr>
<th>401-4944-20L</th>
<th>Mathematics of Data Science</th>
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<th>8 credits</th>
<th>4G</th>
<th>A. Bandeira</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.</td>
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<tr>
<td>Objective</td>
<td>Introduction to various mathematical aspects of Data Science.</td>
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<tr>
<td>Content</td>
<td>These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.</td>
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The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

252-0535-00L Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals: What is data?
- Bayesian Learning
- Computational learning theory
- Supervised learning: Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks
- Unsupervised learning: Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-3005-00L Natural Language Processing

Abstract
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.
Lectures will include: microarray preprocessing; normalization; exploratory data analysis techniques such as clustering, PCA and - Matthews, J. N. S. (2006). Introduction to Randomized Controlled T. Hofmann

A range of topics will be covered, including basic molecular biology, genomics technologies and in particular, a wide range of statistical and Discussion of the different statistical methods that are used in clinical research.

Detailed lecture notes are available on the course web page https://www.mins.ee.ethz.ch/teaching/intnt/ 401-8625-00L

Clinical Biostatistics (University of Zurich) W 6 credits 4G University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: STA404

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Objective

- Discussion of the different statistical methods that are used in clinical research. Among other subjects the following will be introduced: sample size calculation, randomization and blinding, analysis of clinical trials (parallel groups design, analysis of covariance, crossover design, equivalence studies), intention-to-treat analysis, multiple testing, group sequential methods, adaptive designs, diagnostic studies, and agreement studies.


Prerequisites / notice

Basic knowledge of the programming language R, sufficient knowledge in calculus, linear algebra, probability, statistics

263-3210-00L

Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz, N. Perraudin

Number of participants limited to 320.

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Objectives:**
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    - Computational Intelligence Lab
    - Introduction to Machine Learning
    - Statistical Learning Theory
    - Computational Statistics
  - Probabilistic Artificial Intelligence

**Prerequisites / notice:**
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

**Number of participants limited to 30.**

---

**Prerequisites / notice:**
Solid basic knowledge in statistics, algorithms and programming.

**Abstract:**
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Content:**
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bands and Bayesian optimization
- Reinforcement learning

Number of participants limited to 30.
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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### Lectures

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<tr>
<th>W</th>
<th>2 credits</th>
<th>2S</th>
<th>F. Balabdaoui</th>
</tr>
</thead>
</table>

### Main Goals
- The students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).

### Prerequisites
- Students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.
- Successful participation in the course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics.
- Also offered in the Master Programmes Statistics resp. Data Science.

### Content
- **Linear regression** is one of the most used models for prediction and hence one of the most understood in statistical literature. However, linearity might be too simplistic to capture the actual relationship between some response and given covariates. Also, there are many real data problems where linearity is plausible but the actual pairing between the observed covariates and responses is completely lost or at partially. In this seminar, we review some of the non-classical regression models and the statistical properties of the estimation methods considered by well-known statisticians and machine learners. This will encompass:
  1. Monotone regression
  2. Single index model
  3. Unlinked regression

### Literature
- **1. Monotone regression**
  - "Nonparametric shape-restricted regression" by A. Guntuynia and B. Sen, 2018, Statistical Science, Volume 33, 568-594
  - "Asymptotic distributions for two estimators of the single index model" by Y. Xia, 2006, Econometric Theory, Volume 22, 1112-1137

- **2. Single index model**
  - "Linear regression with shuffled data: statistical and computation limits of permutation recovery" by A. Pananjady, M. Wainwright and T. A. Courtade, 2018, IEEE transactions in Information Theory, Volume 64, 3286-3300
  - "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS
  - "A pseudo-likelihood approach to linear regression with partially shuffled data" by M. Slawski, G. Diao, E. Ben-David, 2019, arXiv.
  - "Uncoupled isotonic regression via minimum Wasserstein deconvolution" by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27

- **3. Unlinked regression**
  - The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

### Prerequisites / notice
- The student need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.
The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

**Content**

The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

**Literature**

The papers will be presented in the first session of the seminar.

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### Free Electives

Several further courses offered at the University of Zurich belong to the curriculum of the Master's Programme in Statistics. With the consent by the Advisor (http://stat.ethz.ch/~kalisch/) such a course is eligible as a free elective.

### Course Catalogue

#### Science in Perspective

Two credits are needed from the "Science in Perspective" programme with language courses excluded if three credits from language courses have already been recognized for the Bachelor's degree. see https://ethz.ch/content/dam/ethz/common/docs/weisungssammlung/files-en/science-in-perspective.pdf (Eight credits must be acquired in this category: normally six during the Bachelor's degree programme, and two during the Master's degree programme. A maximum of three credits from language courses from the range of the Language Center of the University of Zurich and ETH Zurich may be recognised. In addition, only advanced courses (level B2 upwards) in the European languages English, French, Italian and Spanish are recognised. German language courses are recognised from level C2 upwards.)

**Recommended Science in Perspective (Type B) for D-MATH**

**Recommended Science in Perspective: Language Courses ETH/UZH**

#### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Mathematics</td>
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<td>0 credits</td>
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<td>Target audience:</td>
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<td>Third year Bachelor students:</td>
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<td>Abstract</td>
<td>Introduction to scientific writing for students</td>
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<td></td>
<td>with focus on publication standards and ethical</td>
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<td>issues, especially in the case of citations</td>
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<td>Objective</td>
<td>Learn the basic standards of scientific works in</td>
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<td>mathematics.</td>
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<td>- Types of mathematical works</td>
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<td>- Publication standards in pure and applied</td>
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<td>mathematics</td>
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<td>- Data handling</td>
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<td>- Ethical issues</td>
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<td>Lunch Sessions – Thesis Basics for Mathematics</td>
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<td>Details and registration for the optional MathBib</td>
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<td>training course: <a href="https://www.math.ethz.ch/mathbib-schulungen">https://www.math.ethz.ch/mathbib-schulungen</a></td>
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<td>Optional MathBib training course</td>
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<tr>
<td>401-4990-02L</td>
<td>Master's Thesis</td>
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<td>30 credits</td>
<td>57D</td>
<td>Supervisors</td>
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<td>Only students who fulfill the following criteria</td>
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<td>are allowed to begin with their Master's thesis:</td>
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<td>a. successful completion of the Bachelor's</td>
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<td>programme;</td>
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<td>b. fulfilling of any additional requirements</td>
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<td>necessary to gain admission to the Master's</td>
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<td>programme;</td>
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<td>c. They have acquired at least 16 credits in the</td>
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<td>category &quot;Core courses&quot; for Programme Regulations</td>
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<td>2014 and 40 credits in the category &quot;Main Areas&quot;</td>
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<td>for Programme Regulations 2020.</td>
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<td>Successful participation in the course unit</td>
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<td>Scientific Works in Mathematics is required.</td>
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<td>For more information, see</td>
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<td><a href="http://www.math.ethz.ch/intranet/students/study-">www.math.ethz.ch/intranet/students/study-</a></td>
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<td>administration/theses.html</td>
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<td>Abstract</td>
<td>The master's thesis concludes the study programme</td>
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<td>Thesis work should prove the students' ability</td>
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<td>to independent, structured and scientific</td>
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<td>working.</td>
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<td>Objective</td>
<td>Thesis work should prove the students' ability</td>
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<td>to independent, structured and scientific</td>
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<td>working.</td>
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<tr>
<td>Content</td>
<td>Five-month project to solve a research question.</td>
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<td>The content can be more theoretical (e.g.</td>
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<td>proving a new result) or applied (developing</td>
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<td>new methods or making a very sophisticated</td>
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<td>application and adapting existing methods).</td>
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<tr>
<td>Prerequisites/notice</td>
<td>Supervisors are chosen on a first-come-first-served basis. Collaborations with industry are possible.</td>
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</tbody>
</table>

#### Course Units for Additional Admission Requirements

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2072 of 2345
ECTS

**Textbooks in English:**

- 30R
  - Complex numbers.

- 13R
  - From "Statistics for research" (online)

**Analysis I and II**

Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems.

Systems of linear equations, Gaussian elimination, solution space, matrices, LR decomposition, determinants, structure of linear spaces, Linear Algebra I and II

Linear algebra is an indispensable tool of engineering mathematics. The course is an introduction to basic methods and fundamental concepts of linear algebra and its applications to engineering sciences.

After completion of this course, students are able to recognize linear structures and to apply adequate tools from linear algebra in order to solve corresponding problems from theory and applications. In addition, students have a basic knowledge of the software package Matlab.

The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts of linear algebra and its applications to engineering sciences. The student should have a basic knowledge of the software package Matlab.

**Content**

- 406-0603-AAL
  - Ch 1: The Role of Statistics
  - Ch 2: Populations, Samples, and Probability Distributions
  - Ch 3: Binomial Distributions
  - Ch 4: Sampling Distribution of Averages
  - Ch 5: Normal Distributions
  - Ch 6: Student’s t Distribution
  - Ch 7: Distributions of Two Variables

- 406-0243-AAL
  - Ch 1: The Role of Statistics
  - Ch 2: Populations, Samples, and Probability Distributions
  - Ch 3: Binomial Distributions
  - Ch 4: Sampling Distribution of Averages
  - Ch 5: Normal Distributions
  - Ch 6: Student’s t Distribution
  - Ch 7: Distributions of Two Variables

- 406-0603-AAL
  - Ch 1: Basics
  - Ch 2: The R Environment
  - Ch 3: Probability and distributions
  - Ch 4: Descriptive statistics and tables
  - Ch 5: One- and two-sample tests
  - Ch 6: Regression and correlation

**Literature**

- Gilbert Strang: "Introduction to linear algebra", Wellesley-Cambridge Press: Chapters 1-6, 7.1-7.3, 8.1, 8.2, 8.6
- Textbooks in English:

- Textbooks in German:
  - M. Akveld, R. Sperb: Analysis I, vdf
  - M. Akveld, R. Sperb: Analysis II, vdf
  - L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
  - L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag


406-2604-AAL Probability and Statistics

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to probability and statistics with many examples, based on chapters from the books “Probability and Random Processes” by G. Grimmett and D. Stirzaker and “Mathematical Statistics and Data Analysis” by J. Rice.

Objective
The goal of this course is to provide an introduction to the basic ideas and concepts from probability theory and mathematical statistics. In addition to a mathematically rigorous treatment, also an intuitive understanding and familiarity with the ideas behind the definitions are emphasized. Measure theory is not used systematically, but it should become clear why and where measure theory is needed.

Content
Probability:
Chapters 1-5 (Probabilities and events, Discrete and continuous random variables, Generating functions) and Sections 7.1-7.5 (Convergence of random variables) from the book “Probability and Random Processes”. Most of this material is also covered in Chap. 1-5 of “Mathematical Statistics and Data Analysis”, on a slightly easier level.

Statistics:
Sections 8.1 - 8.5 (Estimation of parameters), 9.1 - 9.4 (Testing Hypotheses), 11.1 - 11.3 (Comparing two samples) from “Mathematical Statistics and Data Analysis”.

Literature

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5</td>
<td>3V+1U</td>
<td>M. Akka Ginosar</td>
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<tr>
<td></td>
<td>Introduction to Linear Algebra</td>
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<td></td>
<td>Basic knowledge of linear algebra as a tool for solving engineering problems. Understanding of abstract mathematical formulation of technical and scientific problems. Together with Analysis we develop the basic mathematical knowledge for an engineer.</td>
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<td></td>
<td>The Modelling competency is taught, applied, and tested, and the Programming competency is applied.</td>
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<td></td>
<td>Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.</td>
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<td>Calculation with MATLAB will be introduced in the first exercise class.</td>
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<td>The Modelling competency is taught, applied, and tested, and the Programming competency is applied.</td>
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<td></td>
<td>The Modelling competency is taught, applied, and tested, and the Programming competency is applied.</td>
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<td>The lecturer will provide course notes.</td>
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<td></td>
<td>K. Nipp, D. Stoffer, Lineare Algebra, VdF Hochschulverlag ETH</td>
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<td>G. Strang, Lineare Algebra, Springer</td>
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<tr>
<td>252-0845-00L</td>
<td>Computer Science I</td>
<td>O</td>
<td>5</td>
<td>2V+2U</td>
<td>C. Cotrini Jimenez, M. Fischer</td>
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<td>The course covers the basic concepts of computer programming.</td>
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<td>Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs. In the course &quot;Computer Science I&quot;, the competency of programming is taught, applied and examined. Furthermore modeling is taught and applied.</td>
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<td>variables, types, control structures, functions, scoping, recursion, object-oriented programming. The programming language is Python.</td>
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<td>The slides and lecture notes will be made available for download on the course website.</td>
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<td>Learn to Code by Solving Problems</td>
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<td>A Python Programming Primer</td>
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<td>Daniel Zingaro</td>
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<td>Python Crash Course A Hands-On, Project-Based Introduction to Programming</td>
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<td></td>
<td>Eric Matthes</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>701-0243-01L</td>
<td>Biology III: Essentials of Ecology</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>C. Buser Moser</td>
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<td></td>
<td>This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.</td>
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<td>The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented.</td>
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<td>A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.</td>
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<td></td>
<td>- Einfluss von Umweltfaktoren (Temperatur, Strahlung, Wasser, Nährstoffe etc.) auf Organismen; Anpassung an bestimmte Umweltbedingungen</td>
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<td></td>
<td>- Populationsdynamik: Ursachen, Beschreibung, Vorhersage und Regulation</td>
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<td>- Interaktionen zwischen Arten (Konkurrenz, Koexistenz, Prädation, Parasitismus, Nahrungsnetze)</td>
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<td>- Lebensgemeinschaften: Struktur, Stabilität, Sukzession</td>
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<td></td>
<td>- Ökosysteme: Kompartimente, Stoff- und Energieflüsse</td>
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<td></td>
<td>- Biodiversität: Variation, Ursachen, Gefährdung und Erhaltung</td>
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<td>- Aktuelle Naturschutzprobleme und -massnahmen</td>
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<td></td>
<td>- Evolutionäre Ökologie: Methodik, Spezialisierung, Koevolution</td>
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<td>Unterlagen, Vorlesungsskript und relevante Literatur sind in Moodle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils spätestens am Freitagmorgen zur Verfügung.</td>
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<td>Aquatische Ökologie: Lampert &amp; Sommer 1999, Limnoökologie. Thieme, 2. Aufl., ca. Fr. 55.:-</td>
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<td>Bohle 1995. Limnische Systeme. Springer, ca. Fr. 50.-</td>
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<tr>
<td>151-0223-10L</td>
<td>Engineering Mechanics</td>
<td>O</td>
<td>4</td>
<td>2V+2U+1K</td>
<td>P. Tiso</td>
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<td></td>
<td>Introduction to engineering mechanics: kinematics, statics and dynamics of rigid bodies and systems of rigid bodies.</td>
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<td>Students can solve problems of elementary engineering mechanics.</td>
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</tbody>
</table>
Content
Basic notions: position and velocity of particles, rigid bodies, planar motion, kinematics of rigid body, force, couple, power.
Statics: static equivalence, force-couple system, center of forces, centroid, principle of virtual power, equilibrium, constraints, statics, friction.
Dynamics: acceleration, inertial forces, d'Alembert's Principle, Newton's Second Law, principles of linear and angular momentum, equations of planar motion of rigid bodies.

Lecture notes
yes, in German

Literature

First Year Examination Block B

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-0241-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>M. Akveld</td>
</tr>
</tbody>
</table>

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems.

Content
Complex numbers. Calculus for functions of one variable with applications. Simple Mathematical models in engineering.

Literature
Klaus Dürrschnabel, "Mathematik für Ingenieure - Eine Einführung mit Anwendungs- und Alltagsbeispielen", Springer; online verfügbar unter:
http://link.springer.com/book/10.1007/978-3-8348-2559-9/page/1

Tilo Arens et al., "Mathematik", Springer; online verfügbar unter:
http://link.springer.com/book/10.1007/978-3-642-44919-2/page/1


Urs Stammbach, "Analysis III" (erhältlich im ETH Store); https://people.math.ethz.ch/~stammb/analysisskript.html

529-2001-02L | Chemistry I       | O    | 4 credits | 2V+2U | J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel |

Abstract
General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
Elementary particles and atoms. Electron configuration of the elements. Periodic system.
4. Basics of chemical thermodynamics
System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
6. Second law of thermodynamics
Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
Law of mass action. Reaction quotient and equilibrium constant. Phase transition equilibrium.
9. Acids and bases
10. Dissolution and precipitation.
Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Literature

Weiterführende Literatur:

Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>102-0004-00L</td>
<td>Introduction into Environmental Engineering</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>P. Molnar, P. Burlando, I. Hajnsek, S. Hellweg, M. Maurer, E. Morgenroth, K. Sperger, R. Stocker, J. Wang</td>
</tr>
</tbody>
</table>

Abstract
In this course students are introduced to how environmental problems in the areas of water quantity and quality, waste production and recycling, air pollution control, are formulated and solved with engineering methods. The course makes a connection between the theoretical Bachelor foundation classes and practical topics of environmental engineering in six main thematic areas.

Objective
After completing this course, the student will be able to:
- formulate key global environmental problems
- develop a systems perspective and solutions to the problems (critical thinking)
- identify and solve simple numerical problems in the domain areas
- understand why/how we use data/models in environmental engineering
- develop own interest in the domain areas and see career opportunities

Content
Topics of study:
0. Introduction – description of the Earth System, main stressors, global warming, introduction into the methods and goals of environmental engineering.
1. Water Science & Engineering – definition of the global water cycle and hydrological regimes, surface/subsurface flow equations (advection, diffusion), water resources management, climate change.
5. Air Quality – air quality parameters, main air pollutants, air quality in cities/indoor, emission control, the plume dispersion model.
6. Earth Observation – satellite observation of the Earth System from space, methods, environmental applications (glaciers, forest, land surface change)

Lecture notes
Course will take place in English and German (bilingual). The English textbook by Masters and Ela (see below) will be complemented by instructors materials to the individual thematic topics. Lecture presentations will be the main study material. There is no formal Script.

Literature
- lecture presentations and selected papers

Bachelor Studies (Programme Regulations 2010)

1. Semester

First Year Examinations (1. Sem.)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0031-01L</td>
<td>Systems Engineering</td>
<td>O</td>
<td>4 credits</td>
<td>4G</td>
<td>B. T. Adey</td>
</tr>
</tbody>
</table>

- Systems Engineering is a way of thinking that helps engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms.
- This course provides an overview of the main principles of Systems Engineering, and includes an introduction to the use of operations research methods in the determination of optimal systems.

Data: 18.08.2022 12:39
The world's growing population, changing demographics, and changing climate pose formidable challenges to humanity’s ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth's growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.

More specifically upon completion of the course, you will have gained insight into:
• how to structure the large amount of information that is often associated with attempting to modify complex systems
• how to set goals and define constraints in the engineering of complex systems
• how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
• how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future
• how to assess values of benefits to stakeholders that are not in monetary units
• how to assess whether it is worth obtaining more information in determining optimal solution
• how to take a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture
• the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.

Content
The weekly lectures are structured as follows:
1   Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. A high-level overview of the main principles of System Engineering. An introduction to the example that we will be working with throughout most of the course. The expectations of your efforts throughout the semester.
2   Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3   Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4   Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5   Analysis – 1/5 – The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, display, weighting, and expected value.
6   Analysis – 2/5 – The idea behind the supply and demand curves and revealed preference methods.
7   Analysis – 3/5 – The concept of equivalence, including the time value of money, interest, life times and terminal values.
8   Analysis – 4/5 – The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Marginal rates of return and internal rates of return.
9   Analysis – 5/5 – How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10  Evaluation of solutions – Regardless how sophisticated an analysis is, it requires that decision makers stand back and critically evaluate the results. This week we discuss the aspects of evaluating the results of an analysis.
11  Operations research – 1/4 – Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. This week we discuss linear programming and the simplex method.
12  Operations research – 2/4 – How sensitivity analysis is conducted using linear programming.
13  Operations research – 3/4 – How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
14  Operations research – 4/4 – How to set up and solve problems when there are multiple objectives.

The course uses a combination of qualitative and quantitative approaches. The quantitative analyses requires the use of Excel. An introduction to Excel will be provided in one of the help sessions.

Abstract
This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups.

Objective
This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts.

<table>
<thead>
<tr>
<th>651-0032-00L</th>
<th>Geology and Petrography</th>
<th>O</th>
<th>4 credits</th>
<th>2V+1U</th>
<th>K. Rauchenstein, M. O. Saar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts.</td>
<td></td>
<td></td>
<td></td>
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</table>
### 3. Semester

#### Compulsory Courses 3. Semester

#### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0023-01L</td>
<td>Physics</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>S. Johnson</td>
</tr>
<tr>
<td>101-0203-01L</td>
<td>Hydraulics I</td>
<td>O</td>
<td>5 credits</td>
<td>3V+1U</td>
<td>R. Stocker</td>
</tr>
<tr>
<td>103-0233-01L</td>
<td>GIS I (for Environmental Engineers)</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>P. Kiefer</td>
</tr>
<tr>
<td>102-0293-00L</td>
<td>Hydrology</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>P. Burlando</td>
</tr>
</tbody>
</table>

#### Abstract

- **Physics**: This course gives an overview of important concepts in classical dynamics, thermodynamics, electromagnetism, quantum physics, atomic physics, and special relativity. Emphasis is placed on demonstrating key phenomena using experiments, and in developing skills for quantitative problem solving.

- **Hydraulics I**: The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.

- **GIS I (for Environmental Engineers)**: Fundamentals of geoinformation technologies: spatial data modeling, metrics & topology, vector and raster data, thematic data, spatial queries and analysis, spatial databases; lab sessions with GIS software.

- **Hydrology**: The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.

#### Literature


- **Hydraulics I**: Lecture notes and exercise sheets will be distributed via Moodle.


Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.

The hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

Precipitation: mechanisms of precipitation formation, precipitation measurements, variability of precipitation in space and time, precipitation regimes, point basin precipitation, isochetal method, Thiessen polygons, storm rainfall, design hyetograph.

Interception: measurement and estimation.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton’s equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnian surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – baseflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rationale, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Snow (and ice) hydrology: snow characteristic variables and measurements, estimation of snowmelt processes by the energy budget equation and conceptual melt models (temperature index method and degree-day method), snowmelt runoff.

The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.


Knowledge of statistics is a prerequisite. The theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:

Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters), Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

Further aims of the lecture are that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.

Ecological concepts are exemplified by using aquatic and terrestrial examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented.

A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.

Knowledge of statistics is a prerequisite. The theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:

Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters), Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research.

The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented.

Further aims of the lecture are that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.

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Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters), Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.
Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.
Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

Objective
Students are able to understand
- the structure and function of biological macromolecules
- the kinetic bases of enzyme reactions
- thermodynamic and mechanistic basics of relevant metabolic processes
Students are able to describe the relevant metabolic reactions in detail

Content
Program
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Carbohydrates
Lipids and biological membranes
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design, Repetition of basic thermodynamics
Glycolysis, fermentation
The citric acid cycle
Oxidative phosphorylation
Fatty acid metabolism

Lecture notes
Horton et al. (Pearson) serves as lecture notes.

Prerequisites / notice
Basic knowledge in biology and chemistry is a prerequisite.

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies not assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Lecture notes
Written material will be available digital.

Prerequisites / notice
Prerequisite: Introduction to Urban Water Management

5. Semester
Compulsory Courses 5. Semester

Urban Water Management II

Abstract

Objective
Consolidation of the basic procedures for design and operation of technical networks in water engineering.

Content
Demand Side Management versus Supply Side Management
Optimierung von Wasserversorgungsnetzen
Kalkaufsättigung, Korrosion von Leitungen
Hygiene in Verteilsystemen
Siedlungshydrologie: Niederschlag, Abflussbildung
Instationäre Strömungen in Kanalisationen
Stofftransport in der Kanalisation
Einleitbedingungen bei Regenwetter
Versickerung von Regenwasser
Generelle Entwässerungsplanung (GEP)

Lecture notes
Written material will be available digital.

Prerequisites / notice
Prerequisite: Introduction to Urban Water Management
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Communication</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### 102-0455-01L Groundwater I

<table>
<thead>
<tr>
<th>Abstract</th>
<th>The course provides a quantitative introduction to groundwater flow and contaminant transport.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>In &quot;Groundwater I&quot; the competencies of process understanding are taught, applied and examined. Furthermore, system understanding and concept development are taught and applied, which are previous steps to groundwater modeling. To add measurement methods are taught and data analysis &amp; interpretation is applied during the course.</td>
</tr>
<tr>
<td>Content</td>
<td>Understanding of the basic concepts on groundwater flow and contaminant transport processes. Formulation and solving of practical problems.</td>
</tr>
<tr>
<td>Literature</td>
<td>Properties of porous and fractured media, Darcy’s law, flow equation, stream functions, interpretation of pumping tests, transport processes, transport equation, analytical solutions for transport, numerical methods: finite differences method, aquifers remediation, case studies.</td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Script and collection of problems available</td>
</tr>
<tr>
<td>Literature</td>
<td>P.A. Freeze, J.A. Cherry, Groundwater, Prentice-Hall, New Jersey, 1979</td>
</tr>
<tr>
<td>Literature</td>
<td>W. Kinzelbach, R. Rausch, Grundwassermodellierung, Gebrüder Bornträger, Stuttgart, 1995</td>
</tr>
</tbody>
</table>

### 102-0635-01L Air Pollution Control

| Abstract | The lecture provides in the first part an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and their impact on air quality. The second part covers different strategies and techniques for emission reduction. The basic knowledge is deepened by the discussion of specific air pollution problems of today’s society. |
| Objective | The students gain general knowledge of the technical processes resulting in air pollution and study the methods used for air pollution control. They can incorporate general knowledge of air pollution sources and understand the methods for measuring pollutants, collecting and analyzing data. The students can suggest and evaluate possible control methods and equipment, design control systems and estimate their efficiency and efforts. The students know the different strategies of air pollution control and are familiar with their scientific fundamentals. They are able to incorporate goals concerning air quality into their engineering work. |
| Content | Properties of porous and fractured media, Darcy’s law, flow equation, stream functions, interpretation of pumping tests, transport processes, transport equation, analytical solutions for transport, numerical methods: finite differences method, aquifers remediation, case studies. |
| Lecture notes | Script and collection of problems available |
| Literature | J. Bear, Air pollution control, Part I |
| Literature | Jing Wang, Air pollution control, Part II |
| Literature | Lecture slides and exercises |

### Prerequisites / notice

- College lectures on basic physics, chemistry and mathematics.
- Language of instruction: In German or in English.
Learning Outcomes

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Abstract

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

Objective

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:

1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

Content

Die Lehrveranstaltung gibt einen Einblick in die heutige Erdbeobachtung mit dem folgenden skizzierten Inhalt:

1. Einführung in die Fernerkundung von Luft- und Weltraum gestützten Systemen
2. Einführung in das Elektromagnetische Spektrum
3. Einführung in optische Systeme (optisch und hyperspektral)
4. Einführung in Mikrowellen-Technik (aktiv und passiv)
5. Einführung in atmosphärische Systeme (meteo und chemisch)
6. Einführung in die Techniken und Methoden zur Bestimmung von Umweltparametern
7. Einführung in die Anwendungen zur Bestimmung von Umweltparametern in der Hydrologie, Glaziologie, Forst und Landwirtschaft, Geologie und Topographie

Literature

Ausgewählte Literatur wird am Anfang der Vorlesung vorgestellt.
Lecturers not assessed

Weitere Literaturangaben folgen in der Vorlesung

Media and Digital Technologies
2 credits
2V
E. Secchi assessed

ECTS not assessed

Environmental Engineering Seminars
not assessed

Hours

Title

, P. Burlando, I. Hajnsek, E. Secchi, A. Gossweiler, C. Jäger, M. Pflüger

The course is organized in the form of seminars held by the students. Topics selected from the core disciplines of the curriculum (water resources, urban water engineering, material fluxes, waste technology, air pollution, earth observation) are discussed in the class on the basis of scientific papers that are illustrated and critically reviewed by the students.

R. Stocker, J. Wang

C. G. C. March

The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project. Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company wide success.

No. The lecture slides and other additional material will be available for download from Moodle a week before each class.

Environmental Law I: Fundamentals and Concepts
0 2 credits 2V
A. Gossweiler, C. Jäger, M. Pflüger
Only for Environmental Engineering BSc

Abstract
This class introduces students to the fundamentals of legal systems, focusing on environmental law. It covers the fundamentals of constitutional and administrative law, as opposed to private and criminal law. The class will focus on concepts, terminology and procedures of Swiss environmental law and selected aspects of European environmental law, supplemented through case studies.

Objective
Students learn fundamental structures of the legal system, understand core concepts and selected problems of public law, focusing on Swiss and European environmental law. These insights can be applied in further law courses, in particular in the course "Environmental law: Areas and Case Studies."

Content

Lecture notes
Christoph Jäger/Andreas Bühler, Schweizerisches Umweltrecht, Bern 2016

Literature
Weitere Literaturangaben folgen in der Vorlesung

Project Management
0 2 credits 2G
C. G. C. Marx

Abstract
The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

Objective
The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project. Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Content
Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Lecture notes
No.

Additional Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
The course is organized in the form of seminars held by the students. Topics selected from the core disciplines of the curriculum (water resources, urban water engineering, material fluxes, waste technology, air pollution, earth observation) are discussed in the class on the basis of scientific papers that are illustrated and critically reviewed by the students.

Objective
Learn about recent research results in environmental engineering and analyse practical applications in environmental engineering.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessment not assessed
Techniques and Technologies assessment not assessed

Method-specific Competencies
Analytical Competencies assessment not assessed
Decision-making assessment not assessed
Media and Digital Technologies assessment not assessed
Problem-solving assessment not assessed
Project Management assessment not assessed

Social Competencies
Communication assessment not assessed
Cooperation and Teamwork assessment not assessed
Customer Orientation assessment not assessed
Leadership and Responsibility assessment not assessed
Self-presentation and Social Influence assessment not assessed
Sensitivity to Diversity assessment not assessed
Negotiation assessment not assessed

Personal Competencies
Adaptability and Flexibility assessment not assessed
Creative Thinking assessment not assessed
Critical Thinking assessment not assessed
Integrity and Work Ethics assessment not assessed
Self-awareness and Self-reflection assessment not assessed
Self-direction and Self-management assessment not assessed

Elocete Blocks

Elective Block: Environmental Planning

Election Block:

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
Physikalische Grundlagen: Schalldruck, Wellen, Quellenarten.

Content
- Schallphysik: Physikalische Grundlagen: Schalldruck, Wellen, Quellenarten.
- Lärmwirkungen: Gehör, Gesundheitliche Wirkungen von Lärm, Störung/Belästigung, Belastungsmasse.
- Schallausbreitung im Freien: Abstandsgesetze, Luftdämpfung, Bodeneffekt, Abschirmung, Reflexion, Streuung, Bebauung, Wettereinfüße.
- Kurze Einführung in die Bauakustik und in die einfachsten Grundlagen der Raumakustik.
- Lärmmäßen und Prognoseverfahren: Messen/Berechnen, Straßenlärm, Eisenbahnlärm, Fluglärm, Schiesslärm, Industrielärm.

Lecture notes / notice
- Skript "Lärmbekämpfung" als PDF ab Beginn der Vorlesung verfügbar.

Elective Block: Soil Protection

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
701-0501-00L | Pedosphere | W | 3 | 2V | R. Kretzschmar
701-0533-00L | Soil and Water Chemistry | W | 3 | 2G | R. Kretzschmar, D. I. Christl, L. Winkel

Elective Block: Civil Engineering

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
101-0339-00L | Environmental Geotechnics | W | 3 | 2G | M. Plötze
Objective
Introduction of basic knowledge about problems with contaminated sites, investigation of this sites, risk management, remediation and reclamation techniques as well as monitoring systems. Introduction in landfill design and engineering with focus on barrier- and drainage systems as well as lining materials, evaluation of geotechnical problems, e.g. stability. In the course "Environmental Geotechnics", the competencies of process understanding, system understanding, concept development, and measurement methods are taught and examined.

Content
Definition of contaminated sites, site investigation methods, historical research and technical investigation, risk assessment, contamination transport, remediation, clean-up and retaining techniques (e.g. bioremediation, incineration, retaining walls, pump-and-treat, permeable reactive barriers), monitoring, research projects and results of waste, waste disposal, treatment and management, multi-barrier-systems, site investigation, lining systems and recovering systems of landfill (e.g. materials, drainage systems, geosynthetics), stability, research projects and results of landfill engineering.

Prerequisites / notice
Lectures and exercises will be distributed after each lecture via moodle platform; additional materials to be accessed online (wileyplus).

ECTS
- 227-1635-00L Theory of Structures (for Environmental Engineering) W 3 credits 2.5G B. Sudret
Only for Environmental Engineering BSc.

Abstract
Introduction to structural mechanics, statically determinate beams and frame structures, trusses. Stresses in statically determinate structures.

Objective
- Understanding the response of elastic beam and frame structures
- Ability to correctly apply the equilibrium conditions
- Understanding the basics of continuum mechanics
- Computation of stresses in elastic structures

Content
- Equilibrium, reactions, static determinacy
- Internal forces (normal and shear forces, moments)
- Arches and cables
- Elastic trusses
- Influence lines
- Basics of continuum mechanics
- Stresses in elastic beams

Lecture notes
Bruno Sudret, "Einführung in die Baustatik", 2021
Available on Moodle with exercises.

Literature
B. Sudret, Baustatik - eine Einführung, 2022, Springer Vieweg.

Elective Block: Energy
At least 10KP must be achieved for the elective block: Energy.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
227-1635-00L | Electric Circuits | W | 4 credits | 3G | D. Shchetinin

Students without a background in Electrical Engineering must take "Electric Circuits" before taking "Introduction to Electric Power Transmission: System & Technology"

Abstract
Introduction to analysis methods and network theorems to describe operation of electric circuits. Theoretical foundations are essential for the analysis of the electric power transmission and distribution grids as well as many modern technological devices – consumer electronics, control systems, computers and communications.

Objective
At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyse simple electric circuits with RLC elements, apply circuit theorems to simple meshed circuits, analyze AC circuits in a steady state and understand the connection of the explained principles to the modelling of the 3-phase electric power systems.

Content
Course will introduce electric circuits variables, circuit elements (resistive, inductive, capacitive), resistive circuits and theorems (Kirchhoffs' laws, Norton and Thvenin equivalents), nodal and mesh analysis, superposition principle; it will continue by discussing the complete response circuits (RLC), sinusoidal analysis – ac steady state (complex power, reactive, active power) and conclude with the introduction to 3-phase analysis.

Lecture notes
lecture and exercises slides will be distributed after each lecture via moodle platform; additional materials to be accessed online (wileyplus)
Literature
Richard C. Dorf, James A. Svoboda
Introduction to Electric Circuits, 9th Edition
Online materials: https://www.wileyplus.com/
Lecture slides and exercises slides

Prerequisites / notice
This course is intended for students outside of D-ITET. No prior course in electrical engineering is required

151-1633-00L Energy Conversion W 4 credits 3G I. Karlin, G. Sansavini
This course is intended for students outside of D-MAVT.

Abstract
This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.

Objective
Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes; Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to building up students' intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

Content
1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

Lecture notes
Lecture slides and supplementary documentation will be available online.

Literature

Prerequisites / notice
This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

Electives
The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

Electives ETH Zurich
Course Catalogue of ETH Zurich

Science in Perspective

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Bachelor's Thesis

Number Title Type ECTS Hours Lecturers
102-0006-00L Bachelor's Thesis O 10 credits 21D Supervisors
Abstract
The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work.

Objective
Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

Content
The contents base upon the fundamentals of the Bachelor Programme. Students can choose from different subjects and tasks. The thesis consists of both a written report and an oral presentation.

Environmental Engineering Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Environmental Engineering Master

Majors

Major Urban Water Management

Ecological System Design

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>102-0307-01L</td>
<td>Advanced Environmental, Social and Economic Assessments</td>
<td>O</td>
<td>5 credits</td>
<td>4G</td>
<td>A. E. Braunschweig, S. Pfister</td>
</tr>
</tbody>
</table>

Abstract
This course deepens students' knowledge of environmental, economic, and social assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

Content
Part I (Advanced Environmental Assessments):
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small exercises related to course issues.

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilias

Literature
Will be made available.

Prerequisites / notice
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Taught competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

102-0317-03L Advanced Environmental Assessment (Computer Lab) O 1 credit 1U S. Pfister

Abstract
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice

Objective
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.
No courses in autumn semester (HS), only in spring semester (FS).

### Systems Analysis in Urban Water Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0227-00L</td>
<td>Systems Analysis and Mathematical Modeling in Urban Water Management</td>
<td>O</td>
<td>6 credits</td>
<td>4G</td>
<td>E. Morgenroth, M. Maurer</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

**Content**
The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

**Lecture notes**
Copies of overheads will be made available.

**Literature**
There will be a required textbook that students need to purchase:

**Prerequisites / notice**
Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.
Water Infrastructure Planning and Stormwater Management

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
102-0250-00L | Urban Drainage Planning and Modelling | O | 6 credits | 4G | M. Maurer, D. Gregorio, U. Karaus, J. P. Leitão Correia, J. Rieckermann

Abstract
In this course, the students learn modern urban drainage engineering approaches, critical thinking, decision making in a complex environment as well as dealing with insufficient data and ill-defined problems.

Objective
By the end of the course, you should be able to do the following:
- Apply different methods and methodologies to assess the impact of urban drainage on water pollution and flooding potential.
- Distinguish between hydrological and hydrodynamic models and their correct application.
- Identify the difference between emission and immersion oriented approaches for identifying drainage measures.
- Identify relevant measures, quantify their effects and assess their relative ranking/priority.
- Consider uncertainties and handle correctly incomplete data and information
- Make decisions and recommendations in a complex application case.
- Teamwork. State principles of effective team performance and the functions of different team roles; work effectively in problem-solving teams.
- Communication. Communicate and document your findings in concise group presentations and a written report.

Content
In urban drainage, the complexity of the decision-making, the available methodologies and the data availability have increased strongly. In current environmental engineering practice, the focus shifted from tables and nomograms to sophisticated simulation tools.

The topics cover:
- Integrated urban water management
- Hydrological and hydrodynamic modelling
- Water quality based assessment
- Freshwater ecology
- Hydraulic capacity assessment
- Sewer network operation
- Decision analysis

Prerequisites / notice
Prerequisites: 102-0214-00 Siedlungswasserwirtschaft and 102-0215-00 Siedlungswasserwirtschaft II or comparable educational background.

Major Environmental Technologies
Air Quality Control
Air pollution modeling and chemistry

Abstract
Air pollutants cause negative effects on humans, wildlife and buildings. To control and reduce the impact of air pollutants, their transfer from sources to receptors needs to be known. This transfer includes transport within the atmospheric boundary layer, chemical transformation reactions and phase-transfer processes from gases to particles.

Objective
The students understand the fundamental principles of atmospheric transport, dispersion and chemistry of pollutants on the local to regional scale and their transfer gas to particle phases (secondary aerosols). This includes the knowledge of important atmospheric reactions, sources and sinks. The obtained understanding enables the students to apply computational tools to predict the transport and transformation of chemicals at the local to regional scale.

Content
- Structure of the atmosphere
- Thermodynamics of the atmosphere
- Atmospheric stability
- Atmospheric boundary layer and turbulence
- Dispersion in the atmospheric boundary layer
- Numerical models of atmospheric dispersion
- Gas phase reaction kinetics
- Tropospheric chemistry and ozone formation
- Chemistry box models
- Volatile organic pollutants (VOCs) and semi-volatile organic pollutants (SVOCs)
- Aerosol modelling
- Air pollution source apportionment
- Inverse modelling of emissions

Lecture notes
Continued updates of:
- Slides and handouts
- Home assignments and sample solutions
- R package and code for some of the home assignments
- MATLAB codes
- Key journal articles as discussed during lecture

Literature
Atmospheric chemistry

Environmental organic chemistry and mass transfer
Mackay D., Multimedia environmental models : the fugacity approach; Boca Raton, Fla. : Lewis Publishers; 2001; 2nd ed

Atmospheric dynamics and boundary layer

Atmospheric modelling

Prerequisites / notice
strongly recommended: 102-0635-01L Luftreinhaltung (Air Pollution Control) or similar

Process Engineering in Urban Water Management
No courses in autumn semester (HS), only in spring semester (FS).

System Analysis in Urban Water Management

Number Title Type ECTS Hours Lecturers
102-0277-00L Air Pollution Modeling and Chemistry O 3 credits 2G S. Henne, S. Reimann Bhend, X. Zhang

Number Title Type ECTS Hours Lecturers
102-0227-00L Systems Analysis and Mathematical Modeling in Urban Water Management O 6 credits 4G E. Morgenroth, M. Maurer

Abstract

Objective
The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

Content
The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

Lecture notes
Copies of overheads will be made available.

Literature
There will be a required textbook that students need to purchase:

Prerequisites / notice
Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.
Process Engineering Ia

Abstract
Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective
Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

Content
- Stoichiometry
- Microbial transformation processes
- Introduction to design and modeling of activated sludge processes
- Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice
For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

Waste Recycling Technologies

Abstract
Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

Objective
At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.
Introduction

Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland

Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
Flow sheet basics: Balancing mass flows
Standard processes: batch vs. continuous
Assessment of separation success: Separation function; grade vs. recovery

Separation Processes
Separation according to size and shape (Classification): Screening, Flow separation
Separation according to material properties (Concentration): Manual Sorting, Gravity concentration, Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology, Froth flotation

Lecture notes
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Literature
A list of recommended books will be provided.

Prerequisites / notice
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

102-0337-00L
Landfilling, Contaminated Sites and Radioactive Waste Repositories

Only for Environmental Engineering MSc.

Abstract
Practices of landfilling and remediation of contaminated sites and disposal of radioactive waste are based on the same concepts that aim to protect the environment. The assessment of contaminants that may leach into the environment as a function of time and how to reduce the rate of their release is key to the design of chemical, technical and geological barriers.

Objective
Upon successful completion of this course students are able to:
- assess the risk posed to the environment of landfills, contaminated sites and radioactive waste repositories in terms of fate and transport of contaminants
- describe technologies available to minimize environmental contamination
- describe the principles in handling of contaminated sites and to propose and evaluate suitable remediation techniques
- explain the concepts that underlie radioactive waste disposal practices.

Content
This lecture course comprises of lectures with exercises and guided case studies.
- A short overview of the principles of environmental protection in waste management and how this is applied in legislation.
- A overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes that control redox state and pH buffer capacity; mobility of heavy metals and organic compounds
- Technical barrier design and function. Clay as a barrier.
- Contaminated site remediation: Site evaluation, remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.
The competencies of process understanding, system understanding, concept development, and measurement methods are taught and examined.

Lecture notes
Short script plus copies of overheads

Literature
Literature will be made available.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
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<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
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<td>Problem-solving</td>
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<td>Adaptability and Flexibility</td>
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3 credits

102-0217-00L
Process Engineering Ia

Abstract
Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective
Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

Content
Stoichiometry
Microbial transformation processes
Introduction to design and modeling of activated sludge processes
Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.swi.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice
For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.swi.ifu.ethz.ch/education/lectures/process-engineering-ia.html
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed


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Major Resource Management

Ecological System Design

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</table>

Abstract
This course deepens students' knowledge of environmental, economic, and social assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including ‘organisational LCA’ (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management

Content
Part I (Advanced Environmental Assessments):
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including ‘organisational LCA’ (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small exercises related to course issues.

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilias

Literature
Will be made available.
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
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<td>Problem-solving</td>
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<tr>
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<td>Critical Thinking</td>
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</table>

**102-0317-03L Advanced Environmental Assessment (Computer Lab)**

**Abstract**
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice.

**Objective**
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.

**Taught competencies**

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**Groundwater**

*Module is offered in Spring Semester.*

**Waste Management**

*Remark: 102-0337-00 Landfilling, Contaminated Sites and Radioactive Waste Repositories only for those students also taking module "System Analysis in Urban Water Management" as replacement of 102-0217-00 Process Engineering la in module "Waste Management".*

**Number**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0357-00L</td>
<td>Waste Recycling Technologies</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>R. Bunge</td>
</tr>
</tbody>
</table>

**Abstract**
Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

**Objective**
At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

**Content**
Introduction
Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland
Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
Flow sheet basics: Balancing mass flows
Standard processes: batch vs. continuous
Assessment of separation success: Separation function; grade vs. recovery

**Lecture notes**
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

**Literature**
A list of recommended books will be provided.

**Prerequisites / notice**
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

**102-0337-00L Landfilling, Contaminated Sites and Radioactive Waste Repositories**

**Abstract**
Practices of landfilling and remediation of contaminated sites and disposal of radioactive waste are based on the same concepts that aim to protect the environment. The assessment of contaminants that may leach into the environment as a function of time and how to reduce the rate of their release is key to the design of chemical, technical and geological barriers.

**Objective**
Upon successful completion of this course students are able to:
- assess the risk posed to the environment of landfills, contaminated sites and radioactive waste repositories in terms of fate and transport of contaminants
- describe technologies available to minimize environmental contamination
- describe the principles in handling of contaminated sites and to propose and evaluate suitable remediation techniques
- explain the concepts that underlie radioactive waste disposal practices.

**Content**
This lecture course comprises of lectures with exercises and guided case studies.
- A short overview of the principles of environmental protection in waste management and how this is applied in legislation.
- A overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes that control redox state and pH buffer capacity; mobility of heavy metals and organic compounds
- Technical barrier design and function. Clay as a barrier.
- Contaminated site remediation: Site evaluation, remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

**Lecture notes**
Short script plus copies of overheads

**Literature**
Literature will be made available.

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2096 of 2345
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information). For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

### Water Resources Management

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>102-0468-10L</td>
<td>Watershed Modelling</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>P. Molnar</td>
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</tbody>
</table>

Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.
**Ecohydraulics and Habitat Modelling**

The aims of this course are:
1. To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.
2. To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3. To show the importance of ecosystem services.
4. To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5. To identify and measure the characteristics of landscape.
6. To learn how to use spatial data in landscape planning.

**Numerical Hydraulics**

In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

**Ecohydraulics and Habitat Modelling**

This class will take a broad view of ecohydraulics and introduce students to key concepts in aquatic habitat modeling. Recognizing that an ecosystem is composed of diverse organisms with different seasonal habitat requirements across a range of scales, the class will focus on multiple representative groups of organisms, including fish, macroinvertebrates, plankton, and vegetation. The lectures will build on the students’ knowledge of hydraulics, to give them both an appreciation for the dependence of organisms on their physical environment and a set of quantitative modeling approaches that they can take with them into engineering practice, in fields ranging from hydropower development and upgrade, to reservoir operation, river restoration, flood protection, water management and beyond. At the broadest scale, this class will contribute to the students’ appreciation of the tight link between the natural and the built or impacted environment, and of the imperatives of considering both in the design process.
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice
The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Content
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes
There is no script.

Literature
The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice
Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

Water Resources Management

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<td>Watershed Modelling</td>
<td>O</td>
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Abstract
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.
Content
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

Taught competencies

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<td>assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td></td>
<td>not assessed</td>
<td></td>
</tr>
</tbody>
</table>

Social Competencies
Communication not assessed

Personal Competencies
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Objective
This is the fundamental topic in ecohydraulics, the discipline that focuses on the consequences of fluid flow and related physical processes with regard to economy and safety.

Content
This basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Literature
Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

ECTS
The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.

Content
In this course Numerical Hydraulics the basics of numerical modelling of flows are presented.

Abstract
In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.

Objective
The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.

Content
The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Lecture notes
Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
101-0267-01L | Numerical Hydraulics | O | 3 | 2G | M. Holzner
102-0259-00L | Ecohydrologies and Habitat Modelling | O | 3 | 2G | R. Stocker, K.-D. Jorde, L. G. Martins da Silva, A. Siviglia

Hydraulic Engineering

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
101-0247-01L | Hydraulic structures II | O | 6 | 4G | K. Sperger, I. Albyarayk, F. Evers, B. Hohermuth

Abstract
Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design with regard to economy and safety are provided.

Objective
Knowledge of hydraulic structures and their function within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.

Data: 18.08.2022 12:39
Autumn Semester 2022
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The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

Short practical exercises (voluntary) will be offered throughout the semester to improve the application of the learned subjects.

Recommended lectures:
- Flow and Sedimentation; Pierre Y. Julien
- River Mechanics; Pierre Y. Julien

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

subject-specific competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Communication
- Cooperation and Teamwork
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

Personal Competencies

Self-direction and Self-management not assessed
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zones, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice
Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

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<td>O</td>
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Objective
- The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

Content
- The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
- There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
- Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

### Project Work (for all Majors)

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<th>Lecturers</th>
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<tr>
<td>102-0999-00L</td>
<td>Project Work</td>
<td>O</td>
<td>12 credits</td>
<td>26A</td>
<td>Supervisors</td>
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</tbody>
</table>

Objective
- Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

Content
- The project work is supervised by a professor. Students can choose from different subjects and tasks.

### Elective Modules

#### EM: Air Quality Control

Elective Module for Majors "Resource Management", "River and Hydraulic Engineering" "Urban Water Management" and "Water Resources Management".

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>102-0377-00L</td>
<td>Air Pollution Modeling and Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Henne, S. Reimann Bhend, X. Zhang</td>
</tr>
</tbody>
</table>

Abstract
- Air pollutants cause negative effects on humans, wildlife and buildings. To control and reduce the impact of air pollutants, their transfer from sources to receptors needs to be known. This transfer includes transport within the atmospheric boundary layer, chemical transformations in reactions and phase-transfer processes from gases to particles.

Objective
- The students understand the fundamental principles of atmospheric transport, dispersion and chemistry of pollutants on the local to regional scale and their transfer gas to particle phases (secondary aerosols). This includes the knowledge of important atmospheric reactions, sources and sinks. The obtained understanding enables the students to apply computational tools to predict the transport and transformation of chemicals at the local to regional scale.
Content
- Structure of the Atmosphere
- Thermodynamics of the atmosphere
- Atmospheric stability
- Atmospheric boundary layer and turbulence
- Dispersion in the atmospheric boundary layer
- Numerical models of atmospheric dispersion
- Gas phase reaction kinetics
- Tropospheric chemistry and ozone formation
- Chemistry box models
- Volatile organic pollutants (VOCs) and semi-volatile organic pollutants (SVOCs)
- Aerosol modelling
- Air pollution source apportionment
- Inverse modelling of emissions

Lecture notes
Continued updates of:
- Slides and handouts
- Home assignments and sample solutions
- R package and code for some of the home assignments
- MATLAB codes
- Key journal articles as discussed during lecture

Literature
Atmospheric chemistry

Environmental organic chemistry and mass transfer
Mackay D., Multimedia environmental models : the fugacity approach; Boca Raton, Fla. : Lewis Publishers; 2001; 2nd ed

Atmospheric dynamics and boundary layer

Atmospheric modelling

Introduction to R

Prerequisites / notice
strongly recommended: 102-0635-01L Luftreinhaltung (Air Pollution Control) or similar

EM: Ecological Systems Design
Elective Module for Majors "Environmental Technologies", "River and Hydraulic Engineering" and "Water Resources Management".

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<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>102-0307-01L</td>
<td>Advanced Environmental, Social and Economic Assessments</td>
<td>W</td>
<td>5</td>
<td>4G</td>
<td>A. E. Braunschweig, S. Pfister</td>
</tr>
</tbody>
</table>

Abstract
This course deepens students' knowledge of environmental, economic, and social assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management
Part I (Advanced Environmental Assessments)
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multiprocess processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication.
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small excercises related to course issues.

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilia

Literature
Will be made available.

Prerequisites / notice
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Problem-solving
Personal Competencies
Creative Thinking
Critical Thinking

102-0317-03L Advanced Environmental Assessment (Computer Lab) W 1 credit 1U S. Pfister

Abstract
Different tools and software will be used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice.

Objective
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Personal Competencies
Creative Thinking
Critical Thinking

Autumn Semester 2022

101-0259-00L Ecohydraulics and Habitat Modelling W 3 credits 2G R. Stocker, L. G. Martins da Silva, A. Siviglia

Abstract
At a time in which humans have significantly affected the natural environment and yet society increasingly values the many services of natural ecosystems, accounting for ecological processes in engineering design is a major contemporary challenge for environmental and civil engineers.

Objective
This is the fundamental topic in ecohydraulics, the discipline that focuses on the consequences of fluid flow and related physical processes on the organisms that inhabit aquatic environments. While still a young science, ecohydraulics already endows the engineer with an overall understanding and quantitative tools to predict how physical processes shape habitat quality and quantity, enabling the analysis of different management options for natural and man-made water bodies in terms of their ecosystem consequences.
This class will take a broad view of ecohydraulics and introduce students to key concepts in aquatic habitat modeling. Recognizing that an ecosystem is composed of diverse organisms with different seasonal habitat requirements across a range of scales, the class will focus on multiple representative groups of organisms, including fish, macroinvertebrates, plankton, and vegetation. The lectures will build on the students' knowledge of hydraulics, to give them both an appreciation for the dependence of organisms on their physical environment and a set of quantitative modeling approaches that they can take with them into engineering practice, in fields ranging from hydropower development and upgrade, to reservoir operation, river restoration, flood protection, water management and beyond. At the broadest scale, this class will contribute to the students' appreciation of the tight link between the natural and the built or impacted environment, and of the imperatives of considering both in the design process.

**EM: Groundwater**

*Elective Module for Majors “Environmental Technologies”, “River and Hydraulic Engineering” and “Urban Water Management”.

Module is offered in FS.

**EM: Hydraulic Engineering**


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<tr>
<td>101-0247-01L</td>
<td><strong>Hydraulic structures II</strong></td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>K. Sperger, I. Albayrak, F. Evers, B. Hohermuth</td>
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</tbody>
</table>

**Abstract**

Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design with regard to economy and safety are provided.

**Objective**

Knowledge of hydraulic structures and their functions within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.

**Content**

- Weirs: Weir stability, gates, appurtenant structures, fish up- and downstream passages.
- Conduits: Design of headraces, pressure shafts, and penstocks, constructive details and construction.
- Power plants: Power house and turbine types, design, structure, construction.
- Dams: Types, appurtenant structures (temporary diversions, spillways, bottom and low-level outlets), dam type selection criteria, layout and design of gravity dams, buttress dams, arch dams, rockfill dams with central core or concrete face, measures in the foundation, mass concrete, RCC dams, reservoir siltation and sediment management, dam surveillance.
- Artificial reservoirs: Purpose, layout, sealing, appurtenant structures, environmental aspects.

**Lecture notes**

Manuscript and further documentation is specified in the lecture and in the manuscript.

**Literature**

Information: Because Hydraulic Structures II is strongly based on Hydraulic Engineering (101-0206-00L) it is strongly recommended to have taken this course (101-0206-00L) or a similar one previously.

**Prerequisites / notice**

Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Decision-making, Problem-solving.

Method-specific Competencies: Self-direction and Self-management.

**Personal Competencies**

- Problem-solving
- Decision-making
- Self-direction and Self-management
- Analytical Competencies
- Techniques and Technologies
- Concepts and Theories

**EM: Landscape**


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<tr>
<td>103-0347-00L</td>
<td><strong>Landscape Planning and Environmental Systems</strong></td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Grêt-Regamey</td>
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**Abstract**

In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

**Objective**

The aims of this course are:
1. To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2. To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3. To show the importance of ecosystem services.
4. To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5. To identify and measure the characteristics of landscape.
6. To learn how to use spatial data in landscape planning.

**Content**

In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

**Lecture notes**

No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

**Prerequisites / notice**

The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2105 of 2345
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, (2) Sediment dynamics and transport, (3) River basin erosion and sediment budgets, (4) Sediment production and transport. Each section is designed to provide students with a comprehensive understanding of the geomorphic processes that shape river basins and water bodies. The course will cover topics such as fluvial forms and processes, sediment transport, erosion mechanisms, and the interactions between landforms and water bodies. Students will learn about the principles of landscape evolution and the importance of understanding fluvial system change.

**Objective**
- To provide an understanding of the processes that shape river basins and water bodies
- To develop skills in analyzing and interpreting fluvial systems
- To apply geomorphic concepts to real-world problems

**Content**
- Introduction to fluvial forms and processes
- Sediment dynamics and transport
- River basin erosion and sediment budgets
- Sediment production and transport

**Assessment**
- Written examination
- Project work
- Participation in class discussions

**Prerequisites**
- Basic Hydrology and Watershed Modelling (or contact instructor)

**Literature**
- Scholarly articles
- Textbooks
- Perspectives on fluvial geomorphology (I. H. F. James, 1997)
- Modern river basin management (R. W. Hooke, 1998)

**Course Overview**
- Lectures
- Field trips
- Group discussions

**Contact Information**
- [Instructor's contact information]

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**EM: Process Engineering in Urban Water Management**

Elective Module for Majors "Resource Management", "River and Hydraulic Engineering" and "Water Resources Management".

No courses in autumn semester (HS), only in spring semester (FS).

**EM: Remote Sensing and Earth Observation**


Remark: Students also taking module "Remote Sensing and Earth Observation" as replacement of 102-0617-01L Methodologies for Image Processing of Remote Sensing Data in module "Landscape” have to chose one out following list:
- 701-1674-00L Spatial Analysis, Modelling and Optimisation (FS) or 701-1644-00L Mountain Forest Hydrology (HS).

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
102-0617-00L | Basics and Principles of Radar Remote Sensing for Environmental Applications | W | 3 | 2G | I. Hajnsek

**Abstract**
The course will provide the basics and principles of Radar Remote Sensing (Specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

**Objective**
- To provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation.
- To understand the basics and principles of SAR imaging.
- To learn how to interpret SAR images.

**Content**
The course is an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is as follows:
1. Introduction into SAR basics and principles
2. Introduction into SAR interferometry
3. Introduction into SAR interferometry
4. Introduction into polarimetric SAR interferometry
5. Introduction into SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earthquake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

**Lecture notes**
Handouts for each topic will be provided.
The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

The course starts with the real-aperture radar case and a first introduction to the concept of radar interferometry with applications to topographic mapping and mapping of surface displacements. Based on that, the 2-D imaging concept used in synthetic aperture radar imaging is treated.

Then, we expand further on radar and SAR interferometric (InSAR) concepts and processing steps for single interferograms and stacks of interferograms also using persistent scatterer interferometry (PSI) to measure deformation based on time series of interferometric SAR data.

Finally, the 3-D radar imaging case (SAR tomography) is put into context with PSI/InSAR time series as an extension of the more classical interferometric approaches thereby closing the circle around the strongly related concepts of SAR imaging and interferometry.

Lecture notes
Lecture notes/handouts for each topic will be provided online.

Literature
Additional reading material:
ISBN: 978-0-306-47633-4
https://doi.org/10.1007/0-306-47633-9

Prerequisites / notice
It is highly recommended that the student has previously taken the following courses:
102-0617-00L: Basics and Principles of Radar Remote Sensing
and
102-0617-01L: Methodologies for Image Processing of Remote Sensing Data
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

The course consists of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice
Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

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00L 701-1343-00Latitis

Soil-Plant Water Relations

Number of participants limited to 40.
Priority is given to the target groups: Master Environmental Sciences, Master Agricultural Sciences and Master Environmental Engineering until 29.08.2022.
Waiting list will be deleted 02.10.2022.

Abstract
Water limitation is a primary constraint on plant growth and terrestrial fluxes worldwide. In this course, the principles of water flow in soil and plants are discussed, with particular attention on the effect of drought on root water uptake, transpiration and plant growth. Strategies of plants to tolerate drought are discussed.

Objective
The students are able to: explain and compare systematically the drivers of water stress to plants; to solve the equations of water flow in soil and plants and to calculate plant water status for varying pedoclimatic conditions and plant traits; to critically review and present one research question in soil-plant water relations; to openly debate on the current trends in soil and plant water research.

Content
24.09: Introduction.
01.10: Soil water relations; Principles of soil water retention and soil water flow; Soil hydraulic properties.
08.10: Root water uptake; soil hydraulic constraints on transpiration
15.10: Rhizosphere processes and properties; root-soil contact; root hairs; mycorrhiza; rhizodeposition.
22.10: Water flow in roots and xylem; root anatomy, architecture and plasticity; cavitation.
29.10: Transpiration; Vapor Pressure Deficit; Photosynthesis; Stomatal regulation.
05.11: Soil-plant-atmospheric continuum; Below- and above-ground feedbacks; Soil and atmospheric drivers of transpiration losses.
12.11: Modelling Soil-Plant Water Relations (Concept)
19.11: Modelling Soil-Plant Water Relations (Implementation)
26.11: Plant response to drought and consequences for agriculture and forests. Open questions and introduction to seminar topics.
03.12: Group work in the class
10.12: Seminar (presentation of papers)
17.12: Seminar (presentation of papers)
24.12: Seminar (presentation of papers)

Literature
Lecture notes; selection of articles

Prerequisites / notice
Vadose Zone Hydrology/Environmental Soil Physics (recommended but not required)

EM: System Analysis in Urban Water Management

Elective Module for Majors “Resource Management”, “River and Hydraulic Engineering” and “Water Resources Management”.

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<tr>
<td>102-0227-00L</td>
<td>Systems Analysis and Mathematical Modeling in Urban Water Management</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>E. Morgenroth, M. Maurer</td>
</tr>
</tbody>
</table>

Abstract

Objective
The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

Content
The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

Lecture notes
Copies of overheads will be made available.

Literature

Prerequisites / notice
Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

Taught competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

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<tr>
<td>102-0217-00L</td>
<td>Process Engineering Ia</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>E. Morgenroth</td>
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</tbody>
</table>
Abstract
Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective
Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

Content
Stoichiometry
Microbial transformation processes
Introduction to design and modeling of activated sludge processes
Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice
For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

Taught competencies

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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
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<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptable and Flexibility</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>2G</td>
<td>E. Morgenroth</td>
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Autumn Semester 2022
Waste Repositories

Only for Environmental Engineering MSc.

Abstract
Practices of landfilling and remediation of contaminated sites and disposal of radioactive waste are based on the same concepts that aim to protect the environment. The assessment of contaminants that may leach into the environment as a function of time and how to reduce the rate of their release is key to the design of chemical, technical and geological barriers.

Objective
Upon successful completion of this course students are able to:
- assess the risk posed to the environment of landfills, contaminated sites and radioactive waste repositories in terms of fate and transport of contaminants
- describe technologies available to minimize environmental contamination
- describe the principles in handling of contaminated sites and to propose and evaluate suitable remediation techniques
- explain the concepts that underlie radioactive waste disposal practices.

Content
This lecture course comprises of lectures with exercises and guided case studies.
- A short overview of the principles of environmental protection in waste management and how this is applied in legislation.
- A overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes that control redox state and pH buffer capacity, mobility of heavy metals and organic compounds
- Technical barrier design and function. Clay as a barrier.
- Contaminated site remediation: Site evaluation, remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

The competencies of process understanding, system understanding, concept development, and measurement methods are taught and examined.

Lecture notes
Short script plus copies of overheads

Literature
Lecture notes will be made available.

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

ECTS
6 credits

Waste Recycling Technologies

Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

Objective
At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

Content
Introduction
Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland

Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
Flow sheet basics: Balancing mass flows
Standard processes: batch vs. continuous
Assessment of separation success: Separation function; grade vs. recovery

Separation Processes
Separation according to size and shape (Classification): Screening, Flow separation
Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology, Froth flotation

Lecture notes
A list of recommended books will be provided.

Literature
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Prerequisites / notice
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

EM: Water Infrastructure Planning and Stormwater Management
Elective Module for Majors "Environmental Technologies", "Resource Management", "River and Hydraulic Engineering" and "Water Resources Management"

Number Title Type ECTS Hours Lecturers
102-0250-00L Urban Drainage Planning and Modelling W 6 credits 4G M. Maurer, D. Gregorio, U. Karaus, J. P. Leitão Correia, J. Rieckermann

Only for Environmental Engineers Msc in the module Water Infrastructure Planning and Stormwater
Management:

Abstract
In this course, the students learn modern urban drainage engineering approaches, critical thinking, decision making in a complex environment as well as dealing with insufficient data and ill-defined problems.

Objective
By the end of the course, you should be able to do the following:
- Apply different methods and methodologies to assess the impact of urban drainage on water pollution and flooding potential.
- Distinguish between hydrological and hydrodynamic models and their correct application.
- Identify the difference between emission and immersion oriented approaches for identifying drainage measures.
- Identify relevant measures, quantify their effects and assess their relative ranking/priority.
- Consider uncertainties and handle correctly incomplete data and information
- Make decisions and recommendations in a complex application case
- Teamwork. State principles of effective team performance and the functions of different team roles; work effectively in problem-solving teams.
- Communication. Communicate and document your findings in concise group presentations and a written report.

Content
In urban drainage, the complexity of the decision-making, the available methodologies and the data availability have increased strongly. In current environmental engineering practice, the focus shifted from tables and nomograms to sophisticated simulation tools. The topics cover:
- Integrated urban water management
- Hydrological and hydrodynamic modelling
- Water quality based assessment
- Freshwater ecology
- Hydraulic capacity assessment
- Sewer network operation
- Decision analysis

Prerequisites / notice
Prerequisites: 102-0214-00 Siedlungswasserwirtschaft and 102-0215-00 Siedlungswasserwirtschaft II or comparable educational background.

Taught competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

EM: Water Resources Management

Elective Module for Majors “Environmental Technologies”, and “Urban Water Management”.

Number Title Type ECTS Hours Lecturers
102-0468-10L Watershed Modelling W 6 credits 4G P. Molnar

Abstract
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

Content
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
Literature consists of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed

Method-specific Competencies
- Analytical Competencies: assessed

Social Competencies
- Communication: not assessed

Personal Competencies
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

► Specialized Computer Laboratory

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<td>Experimental and Computer Laboratory I (Year Course)</td>
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<td>D. Braun, F. Evers, M. Florianicic, S. Frei, N. Klein, P. U. Lehmann Grunder, B. Lüthi, S. Pfister, F. Rüssch, D. F. Vetsch, L. von Känel, to be announced</td>
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Abstract
In the Experimental and Computer Laboratory students are introduced to research and good scientific practice. Experiments are conducted in different disciplines of environmental engineering. Data collected during experiments are compared to the corresponding numeric simulations. The results are documented in reports or presentations.

Objective
The student will learn the following skills: basic scientific work, planning and conducting scientific experiments, uncertainty estimations of measurements, applied numerical simulations, modern sensor technology, writing reports.

Content
The Experimental and Computer Laboratory is building on courses in the corresponding modules. Material from these courses is a prerequisite or co-requisite (as specified below) for participating in the Experimental and Computer Laboratory (MODULE: Project in the Experimental and Computer Laboratory):
- WatInfra: Water Network Management
- UWM: SysUWM + ProcUWM: Operation of Lab-WWTP
- AIR: Air Quality Measurements
- WasteBio: Anaerobic Digestion
- WasteRec: Plastic Recycling
- ESD: Environmental Assessment
- GROUND: Groundwater Field Course Kappelen
- WRM: Modelling Optimal Water Allocation
- FLOW: 1D Open Channel Flow Modelling
- LAND: Landscape Planning and Environmental Systems
- RIVER: Discharge Measurements
- HydEngr: Hydraulic Experiments
- RemSens: Earth Observation and Landscape Planning
- SOIL: Soil and Environmental Measurements Lab

Lecture notes
Written material will be available.

103-0347-70L Supplementary Course to Project LAND within Experimental and Computer Lab. I Only for Environmental Sciences MSc.

This is a supplementary course for students in the Laboratory Courses in Environmental Engineering who wish to complete all the exercises in Landscape planning and environmental system, as in the 3CP course 103-0347-01L Landscape Planning and Environmental Systems (GIS Exercises).

Abstract
Supplement course to Project LAND in the Experimental and Computer Lab. Methods for the identification and measurement of landscape structure, changes, functions and services, as well as measures and implementation of landscape planning are deepened.

Elctives
The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

Course Catalogue of ETH Zurich

► Master’s Thesis

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Abstract
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 28 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective
To work independently and to produce a scientifically structured work.

Content
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

► Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG
102-0214-AAL Introduction to Urban Water Management

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). Introduction to Urban Water Management is a self-study course.

Objective
This course provides an introduction and an overview over the topics of urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). It supports the understanding of the interactions of the relevant technical and natural systems. Simple design models are introduced.

Content

Lecture notes

Literature
In this self-study course the students must work through and understand selected sections from the following book


Prerequisites / notice
Some students joining the MSc program in Environmental Engineering at ETH Zürich have to take additional courses from our BSc program. The decision of what courses to take is done at the time of admission at ETH.

Students must understand and be able to discuss the required reading in a 30 min oral exam. The required reading is explained in detail on the website of the professorships of urban water management. Additional information can be asked during the office hours of the professors' assistants.

The required reading and studying should correspond roughly the time invested in the course Siedlungswasserwirtschaft GZ. Students are welcome to ask the assistants (http://www.sww.ifu.ethz.ch/group/teaching-assistants.html) for help with questions they have regarding the reading.

The course on “Introduction to Urban Water Management” is offered at ETH Zürich only in German. Students who can speak and understand German must take the course (Siedlungswasserwirtschaft GZ) and get a passing grade. For students that do not have sufficient German language skills there is a self-study course and they have to take an oral exam.

This course is required for further in depth courses in urban water management.

Prerequisite: Hydraulics I and Hydrology

102-0324-AAL Ecological Systems Analysis

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Methodological basics and application of various environmental assessment tools.

Objective
Students learn about environmental assessment tools, such as material flow analysis, risk assessment, and life cycle assessment. They can identify and apply the appropriate tool in a given situation. Also, they are able to critically assess existing studies.

Content
- Methodological basics of material flow analysis
- Application of these methods to case studies

Lecture notes
No script, but literature available on moodle

102-0325-AAL Waste Management

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
No script, but literature available on moodle

Objective
Script and collection of problems available.

Content
Ecological Systems Analysis

Methodological basics and application of various environmental assessment tools.

Objective
Students learn about environmental assessment tools, such as material flow analysis, risk assessment, and life cycle assessment. They can identify and apply the appropriate tool in a given situation. Also, they are able to critically assess existing studies.

Content
- Methodological basics of material flow analysis
- Application of these methods to case studies

Lecture notes
No script, but literature available on moodle

101-0203-AAL Hydraulics I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.

Objective
Familiarization with the basics of hydromechanics of steady state flows

Content
Properties of water, hydrostatics, continuity, Euler equation of motion, Navier Stokes equation, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids-real fluids, boundary layer, pipe flow, open channel flow, flow in porous media, flow measurements, demonstration experiments in the lecture hall and in the laboratory

Lecture notes
No script, but literature available on moodle

101-0204-AAL Introduction to Urban Water Management

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). Introduction to Urban Water Management is a self-study course.

Objective
This course provides an introduction and an overview over the topics of urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). It supports the understanding of the interactions of the relevant technical and natural systems. Simple design models are introduced.

Content

Lecture notes

Literature
In this self-study course the students must work through and understand selected sections from the following book


Prerequisites / notice
Some students joining the MSc program in Environmental Engineering at ETH Zürich have to take additional courses from our BSc program. The decision of what courses to take is done at the time of admission at ETH.

Students must understand and be able to discuss the required reading in a 30 min oral exam. The required reading is explained in detail on the website of the professorships of urban water management. Additional information can be asked during the office hours of the professors' assistants.

The required reading and studying should correspond roughly the time invested in the course Siedlungswasserwirtschaft GZ. Students are welcome to ask the assistants (http://www.sww.ifu.ethz.ch/group/teaching-assistants.html) for help with questions they have regarding the reading.

The course on “Introduction to Urban Water Management” is offered at ETH Zürich only in German. Students who can speak and understand German must take the course (Siedlungswasserwirtschaft GZ) and get a passing grade. For students that do not have sufficient German language skills there is a self-study course and they have to take an oral exam.

This course is required for further in depth courses in urban water management.

Prerequisite: Hydraulics I and Hydrology

102-0214-AAL Introduction to Urban Water Management

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). Introduction to Urban Water Management is a self-study course.

Objective
This course provides an introduction and an overview over the topics of urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). It supports the understanding of the interactions of the relevant technical and natural systems. Simple design models are introduced.

Content

Lecture notes

Literature
In this self-study course the students must work through and understand selected sections from the following book


Prerequisites / notice
Some students joining the MSc program in Environmental Engineering at ETH Zürich have to take additional courses from our BSc program. The decision of what courses to take is done at the time of admission at ETH.

Students must understand and be able to discuss the required reading in a 30 min oral exam. The required reading is explained in detail on the website of the professorships of urban water management. Additional information can be asked during the office hours of the professors' assistants.

The required reading and studying should correspond roughly the time invested in the course Siedlungswasserwirtschaft GZ. Students are welcome to ask the assistants (http://www.sww.ifu.ethz.ch/group/teaching-assistants.html) for help with questions they have regarding the reading.

The course on “Introduction to Urban Water Management” is offered at ETH Zürich only in German. Students who can speak and understand German must take the course (Siedlungswasserwirtschaft GZ) and get a passing grade. For students that do not have sufficient German language skills there is a self-study course and they have to take an oral exam.

This course is required for further in depth courses in urban water management.

Prerequisite: Hydraulics I and Hydrology
Introduction into the problems of waste handling with the goal to get the ability of seeing and improving the influence of commodities and products with there packaging to the environment - as they are becoming waste. Knowing the different mechanical and chemical processes, which are applicable in the field of waste management.

In the course "Waste Management", the competencies of process understanding, system understanding, modeling, concept development, measurement methods and data analysis & interpretation are taught. The competencies process understanding and system understanding are applied and examined in addition. Concept development is also examined.

This lecture gives a comprehensive overview of the different waste-types and waste handling possibilities:
- Waste composition as a mirror of the human evolution
- Waste definition (formation, amount, energy content, waste composition)
- Several recycling possibilities and processes
- Thermal waste treatment (electricity/district heat as products), including off-gas cleaning and incineration residue handling with regards to the final residue storage in a landfill and the problems which have to be solved there
- Special fields like biological waste handling (composting, fermentation), handling of special wastes and municipal sewage sludge treatment
- Economical aspects

Martin F. Lemann, Christoph Leitzinger, Leo S. Morf: Waste Management
Edition 2020, 433 pages
ISBN 978-3-9525297-0-6

Basic of chemical processes has to be known

Prerequisites / notice

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Groundwater I
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The course provides a quantitative introduction to groundwater flow and contaminant transport.

Objective
In "Groundwater I" the competencies of process understanding are taught, applied and examined. Furthermore, system understanding and concept development are taught and applied, which are previous steps to groundwater modeling. To add measurement methods are taught and data analysis & interpretation is applied during the course.

Understanding of the basic concepts on groundwater flow and contaminant transport processes. Formulation and solving of practical problems.

Properties of porous and fractured media, Darcy’s law, flow equation, stream functions, interpretation of pumping tests, transport processes, transport equation, analytical solutions for transport, numerical methods: finite differences method, aquifers remediation, case studies.

W. Kinzelbach, R. Rausch, Grundwassermodellierung, Gebrüder Bornträger, Stuttgart, 1995

Air Pollution Control
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The lecture provides an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and the impact on air quality. Theoretical description and modeling of these processes, air quality measurement techniques and pollution control techniques are covered.

Objective
The students gain general knowledge of the factors resulting in air pollution and the techniques used for air pollution control. The students can identify major air pollution sources and understand the methods for measurement, data collection and analysis. The students can evaluate possible control methods and equipment, design a control system and estimate the efficiency and cost.

J. Jimenez-Martinez, M. Willmann

Edition 2020, 433 pages
ISBN 978-3-9525297-0-6

J. Wang, B. Buchmann

Edition 2020, 433 pages
ISBN 978-3-9525297-0-6

Data: 18.08.2022 12:39
Autumn Semester 2022
Page 2115 of 2345
**Computer Science II**

**Course Code:** 252-0846-AAL

**Objective:**
Introduction to programming in Java. Procedural foundations of programming and outlook to object oriented programming. Variables, types, measurement concepts to observe ambient air pollution - removal of gaseous pollutants by absorption and adsorption - control of NOx and SOx - fundamentals of particulate control - design and application of wet scrubbers

**Content:**
- the physical and chemical processes leading to emission of pollutants
- air quality analysis
- the meteorological parameters influencing air pollution dispersion
- deterministic and stochastic models, describing the air pollution dispersion
- introduction to programming in Java. Procedural foundations of programming and outlook to object oriented programming. Variables, types, measurement concepts to observe ambient air pollution - removal of gaseous pollutants by absorption and adsorption - control of NOx and SOx - fundamentals of particulate control - design and application of wet scrubbers

**Literature:**
- Text book

**Prerequisites / notice:**
College lectures on basic physics, chemistry and mathematics.

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**Introduction to Water Resources Management**

**Course Code:** 102-0474-AAL

**Objective:**
Introduction to the basics of sustainable water resources management based on relevant hydrological processes, management approaches and mathematical models.

**Content:**
- Introduction to the basics of water resources analysis and management covering the topics of water demand vs availability, water exploitation and reservoir design, aquatic physics, water quality and pollution, water conservation and remediation in rivers, lakes and aquifers, sustainable water use.
- The students will be able to write simple programs and to modify existing programs.
- Working with a professional programming environment (Eclipse).
- Writing small programs.

**Prerequisites / notice:**
- Handouts of slides and additional reading material are provided on the Moodle course webpage (https://moodle-app2.let.ethz.ch/course/view.php?id=14738)
- Literature information is provided either in the handouts or on the Moodle course webpage (https://moodle-app2.let.ethz.ch/course/view.php?id=14738)
- Knowledge from the course “Hydrology” (3rd semester Environmental Engineering) and about basic statistics and probability theory is a prerequisite (not formal).

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**Data: 18.08.2022 12:39**
**Autumn Semester 2022**
**Page 2116 of 2345**
This course offers an introduction to variables, control structures (branch, loop), algorithms and data structures, as well as an outlook to modularisation and object oriented techniques.

In the exercises students train programming skills (in the programming language JAVA). Students can solve the exercises on their own laptop or in the computer labs at ETH. The software used in this course runs on MS Windows, MacOS X and Linux.

Prerequisites:
252-0845-00 Computer Science I (D-BAUG)

529-2001-AAL
Chemistry I and II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature
Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

Taught competencies

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529-2002-AAL
Chemistry II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Chemistry II: Redox reactions, chemistry of the elements, introduction to organic chemistry

Objective
Erweitern der allgemeinen Grundlagen und Erarbeiten einer Basis, um Prozesse in komplexeren Umweltsystemen (Wasser / Luft / Boden) in ihrem zeitlichen und quantitativen Ablauf verstehen und beurteilen zu können.
Content

1. Redox reactions

2. Inorganic Chemistry
   Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronic structure of the elements.

3. Introduction to organic chemistry
   Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups. Reaction mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds), Chemistry of carbonyl and carboxyl groups.

Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronic structure of the elements.

3. Introduction to organic chemistry
   Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups. Reaction mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds), Chemistry of carbonyl and carboxyl groups.

Lecture notes

Literature


Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

752-0100-AAL Biochemistry E- 2 credits 4R C. Frei

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.

Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

Objective
Based on the biology and chemistry courses in the 1. and 2. semester more detailed biochemical knowledge about enzymology, membrane biochemistry, and central metabolism will be presented

Content
Program
- Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
- Structure and function of proteins
- Carbohydrates, structure of DNA
- Lipids and biological membranes
- Enzymes and enzyme kinetics
- Catalytic strategies
- Metabolism: Basic concepts and design. Repetition of basic thermodynamics
- Glycolysis
- The citric acid cycle
- Fatty acid metabolism

Lecture notes
by Laurence A. Moran (Author), Robert A Horton (Author), Gray Scrimgeour (Author), Marc Perry (Author)

Literature
by Laurence A. Moran (Author), Robert A Horton (Author), Gray Scrimgeour (Author), Marc Perry (Author)

Prerequisites / notice
Basic knowledge in biology and chemistry is a precondition.
Hydrology

Ein internes Skript ist zur Verfügung (kostenpflichtig, nur Herstellungskosten)

Communication

Teaching of basic knowledge in microbiology.
M. Ackermann

Microbiology

Concepts and Theories

assessed

Techniques and Technologies

assessed

Analytical Competencies

not assessed

Decision-making

not assessed

Media and Digital Technologies

not assessed

Problem-solving

not assessed

Project Management

not assessed

Adaptability and Flexibility

not assessed

Creative Thinking

not assessed

Critical Thinking

assessed

Integrity and Work Ethics

not assessed

Self-awareness and Self-reflection

not assessed

Self-direction and Self-management

assessed


Die Kopie der Folien zur Vorlesung können auf den Webseiten der Professur für Hydrologie und Wasserwirtschaft herunterladen werden


**Prerequisites / notice**

Vorbereitend zu Hydrologie I sind die Vorlesungen in Statistik. Der Inhalt, der um ein Teil der Übungen zu behandeln und um ein Teil der Vorlesungen zu verstehen notwendig ist, kann zusammengefasst werden, wie hintereinander es beschrieben wird: Elementare Datenverarbeitung; Hydrologische Messungen und Daten, Datenreduzierung (grafische Darstellungen und numerische Kenngrössen).


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**406-0023-AAL**

**Physics**

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

This course gives an overview of important concepts in classical dynamics, thermodynamics, electromagnetism, quantum physics, and special relativity. Emphasis is placed on demonstrating key phenomena using experiments, and in developing skills for quantitative problem solving.

**Objective**

The goal of this course is to make students able to explain and apply the basic principles and methodology of physics to problems of interest in modern science and engineering. An important component of this is learning how to solve new, complex problems by breaking them down into parts and applying approximations.

**Content**

Oscillations and waves in matter

Thermodynamics (temperature, heat, equations of state, laws of thermodynamics, entropy, transport)

Electromagnetism (electrostatics, magnetostatics, circuits, Maxwell's equations, electromagnetic waves, induction, electromagnetic properties of materials)

Overview of quantum and atomic physics

Introduction to special relativity

**Lecture notes**

Lecture notes and exercise sheets will be distributed via Moodle.

**Literature**


Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

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**406-0603-AAL**

**Stochastics (Probability and Statistics)**

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

**Objective**

The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

**Content**

From "Statistics for research" (online)

Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"

Ch 1: Basics
Ch 2: The R Environment
Ch 3: Descriptive statistics and tables
Ch 4: One- and two-sample tests
Ch 6: Regression and correlation
### 406-0141-AAL Linear Algebra

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
Introduction to Linear Algebra and Numerical Analysis for Engineers. This reading course is based on chapters from the book "Introduction to Linear Algebra" by Gilbert Strang (SIAM 2009), and "A first Course in Numerical Methods" by U. Ascher and C. Greif (SIAM, 2011).

**Objective**
To acquire basic knowledge of Linear Algebra and some aspects of related numerical methods and the ability to apply basic algorithms to simple problems.

**Content**
1. Introduction, calculations using MATLAB
2. Linear systems I
3. Linear systems II
4. Scalar- & vektorproduct
5. Basics of matrix algebra
6. Linear maps
7. Orthogonal maps
8. Trace & determinant
9. General vectorspaces
10. Metric & scalarproducts
11. Basis, basisvector & similar matrices
12. Eigenvalues & eigenvectors
13. Spectral theorem & diagonalisation
14. Repetition

**Literature**

**Prerequisites / notice**
Knowledge of elementary calculus

### 406-0242-AAL Analysis II

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
Mathematical tools of an engineer

**Objective**
Mathematics as a tool to solve engineering problems, mathematical formulation of problems in science and engineering. Basic mathematical knowledge of an engineer.

**Content**

**Literature**
Textbooks in English:
- J. Stewart: Multivariable Calculus, Thomson Brooks/Cole
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus

- M. Akveld, R. Sperb, Analysis II, vdf
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

### 406-0243-AAL Analysis I and II

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
Mathematical tools for the engineer

**Objective**
Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems. Basic mathematical knowledge for engineers.

**Content**
Complex numbers.
Calcuslus for functions of one variable with applications.
Simple Mathematical models in engineering.

**Literature**
Textbooks in English:
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus

- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag
## Environmental Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
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<tr>
<td>O</td>
<td>Compulsory</td>
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<td>Recommended, not eligible for credits</td>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
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</tr>
<tr>
<td>W</td>
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### Key for Hours

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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
This course looks into scientific theories and also empirical research methods used in the empirical educational sciences. It is about learning in childhood and adolescence.

**Abstract**
This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**
Thematic Schwerpunkte:
- Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissensstrukturierens; Lernen durch Instruktion und Erklärungen: Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen,

Lernformen:

**Literature**

**Prerequisites / notice**
This course is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

**Course Details**
- **Number**: 851-0240-00L
- **Title**: Human Learning (EW1)
- **Type**: O
- **ECTS**: 2 credits
- **Hours**: 2V
- **Lecturers**: E. Stern

**Abstract**
This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)"

**Objective**
- Understand findings relevant for education
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

**Literature**
- Prof. P. Edelsbrunner

**Prerequisites / notice**
For a rebindigse Semestertunplanung wird urm frühe Anmeldung und persönliches Erscheinung zum ersten Lehrveranstaltungstermin ersucht.
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons in this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM); Common perspectives, controversies and empirical evidence will be discussed.

Abstract
To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues. To develop a critical view on existing research and perspectives.

Objective
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher's work.

Content
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>701-0823-00L</td>
<td>Environmental Education Didactics I</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>C. Colberg, F. Keller</td>
</tr>
</tbody>
</table>

Abstract
Environmental Education Didactics supplies the basic concepts for the application of the contents of the lecture Human Learning (EW1) in environmental education. On the basis of selected environmental topics didactical theories are used practice-oriented, whereas the appliance of different teaching methods is pointed out. In addition a didactical topic is exercised exemplary in an assignment.

Objective
Application of the principles and topics of educational sciences on environmental contexts.

Content
Berufsfielder, Denkansätze, unsere Orientierung, Möglichkeiten der Umweltlehre, Umsetzungen des Stoffes, Wirkungen auf Zuhörer/innen, Konfliktsmanagement; Anwendungen allg. Didaktik z. B. in den Bereichen: Globale Umweltzusammenhänge, Klima, Kreislaufe, Boden als Lebensgrundlage, Abfallwirtschaft, Ökobilanzierung als Beurteilungsgrundlage, Schadstoffe in der Umwelt, Quellenarbeit, Umwelt und Wirtschaft, Medien und Umfeld, Zukunftsperspektiven

Lecture notes
Die Unterlagen zu den behandelten Themen werden über die Polybox abgegeben.

Literature
Gemäss Literaturliste, die jeweils in den Lehrveranstaltungen abgegeben wird.

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<tr>
<td>701-0827-00L</td>
<td>Teaching Internship Including Examination Lessons</td>
<td>O</td>
<td>6</td>
<td>13P</td>
<td>C. Colberg, F. Keller</td>
</tr>
</tbody>
</table>

Abstract
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are assessed as Examination Lessons.
Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content
The students will be able to watch and evaluate the teaching of colleagues and experts. They get profit out of their teaching experiences not only when preparing but also when teaching. Doing so they will be supported by their mentors.
Two lessons of the course will be split off for the examination - procedure.

Lecture notes
Dokumente unter
https://www.ethz.ch/de/studium/didaktische-ausbildung/studienangebot-zulassung/didaktik-zertifikat/dokumente--didaktik-zertifikat-.html
- Raster zum Bericht über das Unterrichtspraktikum im DZ Umweltlehre an der ETH Zürich (PDF)
- Beurteilungsbogen Prüfungslektionen Umweltlehre
- Schriftliche Unterrichtsvorbereitung für Prüfungslektionen (PDF)

Literature
Wird von der Praktikumslehrperson bestimmt.

Environmental Studies TC - Key for Type
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ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
Environmental Sciences Bachelor

Basic Courses I

Environmental Systems I

• Tackling Environmental Problems I

Only for Environmental Sciences BSc.

Each year in the case study we analyse a different topic from the field of sustainable development and develop solutions to it.

Objective

Students are able:
- to carry out research on a given topic and present the results in a structured report which (a) shows the state of knowledge and (b) the need for knowledge and action (UPL I).
- to integrate knowledge of diverse perspectives in a qualitative systems model, to identify problems and to suggest possible solutions from a specific stakeholder's perspective (UPL II).
- name the different roles within a group, explain the role(s) they are suited for, self-organise in groups, identify problems of collaboration and constructively address the problems (UPL I and II).

Content

In the first semester the students compile what is known about the case topic, its principles and challenges. Each group of students makes an inquiry to a given part of the overall problem. The inquiry includes a thematic as well as stakeholder analysis. The results are written in a report and presented at an internal conference.

During synthesis week, which takes place during semester break, the results of the different part inquiries are integrated in a qualitative system model. The students identify specific problems and develop solutions.

In the second semester, students work independently and in exchange with stakeholders on previously identified problems. They develop a sustainability project with concrete measures that they could implement voluntarily in the third semester. The course concludes with the presentation of the student projects on the "Market of Measures".

Most of the time students work independently in groups. Tutors support the students in key steps. Introductions are given for:
- the overall topic of the case study (by external experts),
- inquiry, scientific writing and managing references (by experts of ETH library),
- role behaviour and collaboration in groups,
- preparing reports, posters and presentations,
- qualitative system modelling (SystemIQ),
- developing solutions (design thinking, Checkland's soft systems methodology, sustainability assessment).

Lecture notes

Tutors compile the case study dossier on the basis of the student reports.

Literature

Methodological documentation will be made available on Moodle during the case study together with the relevant background literature.

Taught competencies

Subject-specific Competencies: Concepts and Theories (assessed)

Method-specific Competencies: Project Management (assessed)

Social Competencies: Cooperation and Teamwork, Sensitivity to Diversity (assessed)

Personal Competencies: Critical Thinking, Self-awareness and Self-reflection, Self-direction and Self-management (assessed)

Environmental Systems II

The lecture provides a science-based exploration of environmental aspects from three research fields: earth, climate, and health sciences.

Objective

The students are able to explain important properties of the three environmental systems, to discuss critical drivers, trends and conflicts of their use, and to compare potential solutions.

Content

The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of raw materials and fossil fuels, climate change and its impacts on man and environment, and the spread and control of infectious diseases in the human population and agricultural systems.

Lecture notes

Slides are provided by instructors and are accessible via moodle.

Environmental Systems III

Aquatic ecosystems and their function, water use and its impact, water pollution and water treatment, water and health, water technologies, water & energy.

Forests and agroforest systems, trends and drivers of land use changes, sustainable forest management.

The main functions, trends and challenges of agricultural and food systems are discussed based on the four dimensions of food security (availability, access, utilization of food and stability of the food systems).

Lecture notes

Lecture notes or other documentation are provided by instructors and accessible via moodle.

Biology III: Essentials of Ecology

This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial ecosystems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.

Objective

The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented.

Content

- Einfluss von Umweltfaktoren (Temperatur, Strahlung, Wasser, Nährstoffe etc.) auf Organismen; Anpassung an bestimmte Umweltbedingungen.
- Populationsdynamik: Ursachen, Beschreibung, Vorhersage und Regulation
- Interaktionen zwischen Arten (Konkurrenz, Koexistenz, Prädation, Parasismus, Nahrungsnetze)
- Lebensgemeinschaften: Struktur, Stabilität, Sukzession
- Ökosysteme: Kompartimente, Stoff- und Energieflüsse
- Biodiversität: Variation, Ursachen, Gefährdung und Erhaltung
- Aktuelle Naturschutzprobleme und -massnahmen
- Evolutionäre Ökologie: Methodik, Spezialisierung, Koevolution

Data: 18.08.2022 12:39 Autumn Semester 2022
Unterlagen, Vorlesungsfolien und relevante Literatur sind in Moddle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils spätestens am Freitagmorgen zur Verfügung.

**Literatur**

**Generelle Ökologie:**

**Aquatische Ökologie:**
Lampert & Sommer 1999. Limnökologie. Thieme, 2. Aufl., ca. Fr. 55.-;
Bohle 1995. Limnische Systeme. Springer, ca. Fr. 50.-

**Naturschutzbiologie:**

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**401-0251-00L**  
**Mathematics I**  
O 6 credits  
4V+2U  
A. Cannas da Silva

**Abstract**
This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

**Objective**
Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.

**Content**
1. Single-Variable Calculus:  
   - review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

2. Linear Algebra and Complex Numbers:  
   - systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

3. Ordinary Differential Equations:  
   - separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

**Literature**
- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

**Prerequisites / notice**
Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.

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**529-2001-02L**  
**Chemistry I**  
O 4 credits  
2V+2U  
J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel

**Abstract**
General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

**Objective**
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

**Content**
1. Stoichiometry  
   - Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.

2. Atoms  


4. Basics of chemical thermodynamics  
   - System and surroundings. Description of state and change of state of chemical systems.

5. First law of thermodynamics  

6. Second law of thermodynamics  
   - Entropy. Change of entropy in chemical systems and universe. Reaction entropy.

7. Gibbs energy and chemical potential  

8. Chemical equilibrium  

9. Acids and bases  

10. Dissolution and precipitation  
   - Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

**Lecture notes**
Online-Skript mit durchgerechneten Beispielen.

**Literature**

Weiterführende Literatur:  
Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch)
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
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<tr>
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<td>Leadership and Responsibility</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
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<tr>
<td></td>
<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

### General Biology I

**O** 3 credits 3V

**U. Sauer**, O. Y. Martin, A. Widmer

**Abstract**
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

**Objective**
The understanding of some basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

**Content**
The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

**Week 1-7 by Alex Widmer, Chapters 12-25**

- **12** Cell biology: Mitosis
- **13** Genetics: Sexual life cycles and meiosis
- **14** Genetics: Mendelian genetics
- **15** Genetics: Linkage and chromosomes
- **20** Genetics: Evolution of genomes
- **21** Evolution: How evolution works
- **22** Evolution: Phylogenetic reconstructions
- **23** Evolution: Microevolution
- **24** Evolution: Species and speciation
- **25** Evolution: Macroevolution

**Week 8-14 by Oliver Martin, Chapters 26-34**

- **26** Diversity of Life: Introduction to viruses
- **27** Diversity of Life: Prokaryotes
- **28** Diversity of Life: Origin & evolution of eukaryotes
- **29** Diversity of Life: Nonvascular & seedless vascular plants
- **30** Diversity of Life: Seed plants
- **31** Diversity of Life: Introduction to fungi
- **32** Diversity of Life: Overview of animal diversity
- **33** Diversity of Life: Introduction to invertebrates
- **34** Diversity of Life: Origin & evolution of vertebrates

**Lecture notes**
no script

**Literature**

**Prerequisites / notice**
The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.

#### Additional First Year Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0839-00L</td>
<td>Informatics</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>L. E. Fässler, M. Dahinden</td>
</tr>
</tbody>
</table>

**Abstract**
Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists and tables and with relational databases, introduction to programming.

**Objective**
The students learn to:

- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

**Content**
1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python

**Lecture notes**
All materials for the lecture are available at www.evim.ethz.ch.

**Prerequisites / notice**
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

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*Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2128 of 2345*
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<td>Project Management</td>
<td>not assessed</td>
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</tbody>
</table>

### Social Competencies

| Communication | not assessed |

### Personal Competencies

| Adaptability and Flexibility | not assessed |
| Creative Thinking | not assessed |
| Critical Thinking | not assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and Self-management | not assessed |

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### 529-0030-00L

**Laboratory Course: Elementary Chemical Techniques**

<table>
<thead>
<tr>
<th>Number</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0624-00L</td>
<td>Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R. The lecture will be held in German.</td>
</tr>
<tr>
<td>529-0030-00L</td>
<td>The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytic and synthetic tasks. Selected samples (e.g. soil and water) will be analysed with various methods, such as titrations, spectrophotometry or ion chromatography. The chemistry of aqueous solutions (acids-base equilibria and solvation or precipitation processes) is studied. The synthesis of simple inorganic complexes or organic molecules is practised. Furthermore, the preparation and handling of environmentally relevant gaseous substances like carbon dioxide or nitrogen oxides is a central subject of the Praktikum.</td>
</tr>
</tbody>
</table>

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### 751-0801-00L

**Fundamentals of Microscopy and Plant Biology**

<table>
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<tr>
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<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0063-00L</td>
<td>Introduction to the concepts and tools in Physics, with the help of demonstration experiments. The Chapters treated are Electromagnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena. Whenever possible, examples relevant to the students’ main field of study are given.</td>
</tr>
</tbody>
</table>

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### Basic Courses II

#### Examination Blocks

**Examination Block 1**

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0624-00L</td>
<td>O</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>J. Ernest</td>
</tr>
<tr>
<td>402-0063-00L</td>
<td>O</td>
<td>5 credits</td>
<td>3V+1U</td>
<td>A. Vaterlaus</td>
</tr>
</tbody>
</table>

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### Literature

**For further reading (not obligatory):**

- Gerhard Wanner: Mikroskopisch-Botanisches Praktikum, Georg Thieme Verlag, Stuttgart.
- A thorough study of all script materials is requested before the course starts.

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**Groups of a maximum of 30 students.**

**Details will be provided on the first day of the semester.**

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**Examination Blocks**

**Safety concept:** https://chab.ethz.ch/studium/bachelor1.html

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**Voraussetzungen:** Mathematik I, II

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**A script will be distributed**
Lecturers:
- T. Peter 
- Hans J. Paus
- Paul A. Tipler
- David Halliday

Polybook:
- Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and
- Atmosphere
- Mathematics III: Systems Analysis

ECTS Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Overhead slides will be made available through the course website.

Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

2V Teaching of basic knowledge in microbiology.

Mathematics III: Systems Analysis
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer. Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Pedosphere
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples. The course "Pedosphäre" teaches and examines the competences process understanding and systems understanding.

Prerequisites / notice
- Prerequisites: Basic knowledge in chemistry, biology and geology.
Working in a laboratory forms an important part of modern scientific education. Using simple experimental setup the laboratory course will provide basic knowledge of:

- the setup of experiments,
- various measurement techniques,
- the use of various measurement instruments,
- the correct performance of experiments,
- the analysis of the accuracy of the measurements,
- and the interpretations of the measured quantities.

The course will also deepen the knowledge of experimental physics.

In addition to experiments selected from the physics lab for physicists, this lab course offers experiments specially developed for bachelor students in environmental sciences, which illustrate the mutual relationships between physical processes and chemical and biological phenomena.

Content
The students select 4 out of 18 offered experiments which they like to perform. For each of these experiments the students document and analyze their measurements, estimate in written reports the accuracy of their results and compare these with the values expected according to the laws of physics.

Lecture notes
Manuals for the experiments are provided online on the Moodle pages of the course.

### Social Sciences and Humanities

#### Compulsory

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0707-00L</td>
<td>Analyzing Arguments in Science and Ethics</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>C. Jaumberger</td>
</tr>
</tbody>
</table>

Abstract
Problems of the environment and sustainable development are complex from a scientific as well as from an ethical point of view. Addressing them requires the ability to deal with arguments. This course provides basic knowledge and methods for reconstructing, analysing and evaluating arguments. We exercise and improve these abilities by using examples from science, ethics and political debates.

Objective
Students acquire basic knowledge and methods for analyzing arguments. They are able to apply these methods to complex arguments concerning scientific and ethical questions about the environment and sustainable development, and to construct their own arguments and apply them successfully. Moreover, they are able to evaluate the contribution of arguments to controversial debates with the help of rules. Students acquire thereby a crucial skill for Critical Thinking, which aims at responsible argumentation, communication and action.

Content
In the sciences as well as in public discussions or in our everyday life, we try to convince others or to achieve consent in matters of disagreement. We do this with the help of arguments. But what are the criteria for arguments to be convincing and for claims to be clear? And how do we expediently feed arguments into a debate? How can we identify and avoid fallacies in reasoning? How do we analyse and define concepts? This course provides basic knowledge of conceptual analysis and argumentation theory as well as methods for identifying, reconstructing and evaluating claims and arguments. Its focus is on systematically addressing the following two questions: What do you mean? How do you know? The first question aims at a better understanding of the claim in question, the second at assessing the reasons that support or undermine the claim. We exercise and improve the abilities to address these questions by using texts on scientific and ethical questions concerning the environment and sustainable development. The course provides thus crucial skills for Critical Thinking, which aims at responsible argumentation, communication and action.

Lecture notes
Handouts will be available.

Literature

Prerequisites / notice
This is a compulsory course in the social sciences and humanities in the second year of the BA Environmental sciences. For 2 ECTS credits, all written tasks that are distributed during the course need to be solved.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0747-00L</td>
<td>Environmental Policy of Switzerland</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>E. Lieberherr</td>
</tr>
</tbody>
</table>

Abstract
This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples.

Objective
Beyond acquiring basic knowledge about public policy analysis, this course teaches students how to analytically address current and concrete questions of environmental policy. Through exercises the students learn about political science concepts and frameworks as well as real-life political decision-making processes. The well-grounded examination of actual political conflict situations is an important precondition for the entry into the environmental policy workforce or a future research career.

Content
The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

Lecture notes
The reader and additional lecture material and exercises will be posted on Moodle.
Literature
Reader and additional lecture material on moodle.

Prerequisites / notice
The detailed semester program (syllabus) is made available to the students at the beginning of the semester.
During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.

Taught competencies

Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Social Competencies
Sensitivity to Diversity assessed
Personal Competencies
Critical Thinking assessed
Self-direction and Self-management assessed

Prerequisites / notice
Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Principles of Economics
Not for students belonging to D-MTEC!

351-1158-00L

Abstract
This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

Objective
After successful completion of the course you will be able to:
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Content
Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Lecture notes
no script available

Literature

Environmental Law
Only for Environmental Sciences BSc.

851-0738-04L

Abstract
Environmental law regulates the protection of human beings and their environment, such as animals, plants, habitats, soil, waters and air. It plays an increasing role in relation to public and private projects. The lecture gives an overall view of Swiss environmental law. Specific subjects will be dealt with in more detail based on case studies and group work.

Objective
The students are able:
- to apply environmental law in a specific case.
- to explain in which cases the basic principles and the particular instruments of environmental law apply.
- to identify the shortcomings of environmental law and the legislative needs in this regard.
- to describe the tasks and competencies of environmental scientists compared to those of lawyers.

Electives
Module Economics

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0757-00L</td>
<td>Environmental Management</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>R. Züst</td>
</tr>
</tbody>
</table>

Abstract
An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

Objective
Overview on environmental management and environmental management systems, general methods and principles.
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

**Content**

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Students following this course should also be enrolled for course 361-0778-00L, "Discovering Management (Exercises)". This course can be complemented with Discovering Management (Exercises) 351-0778-01.

**Prerequisites / notice**

Delivery of a case study, worked out in groups. Language: Teaching in English on request.

**Literature**

A list with literatures and links will be provided.

**Taught competencies**

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<td>Problem-solving</td>
<td></td>
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</table>

**Content**

Discovering Management (Exercises) is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

**Objective**

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger exercise.

**Content**

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

Students have the option to either write this alone or in a group of two students.

**Taught competencies**

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**Content**

Corporate Sustainability is an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**

The general objective of Corporate Sustainability is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

**Content**

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management (Exercises)". This course can be complemented with Discovering Management (Exercises) 351-0778-01.

**Prerequisites / notice**

Delivery of a case study, worked out in groups. Language: Teaching in English on request.

**Literature**

A list with literatures and links will be provided.

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</table>
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international climate change and climate policy problems.

Students acquire a deeper understanding of basic microeconomic models. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills in the context of corporate sustainability using an innovative writing and peer review method.

In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

For more information, please visit the course website:
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Method-specific Competencies

Techniques and Technologies assessed

International Aid and Development

851-0626-01L

International Aid and Development

W 2 credits 2V I. Günther

Does not take place this semester.

Prerequisites: Basic knowledge of economics

Abstract

The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.

Objective

Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid.

Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.

Content

Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

Literature

Articles and book abstracts will be uploaded to a course website.

Module Political and Social Sciences

851-0577-00L

Principles of Political Science

W 4 credits 2V+1U T. Bernauer

Abstract

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

Objective

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

Content

Der Kurs findet vor Ort statt und wird weder online gestreamt noch aufgezeichnet.


Leistungskontrollen

a) Erster Test (...)

b) Zweiter Test (...)

Ergeben gemittelt das Ergebnis der benoteten Semesterleistung

Kreditpunkte

4 ECTS-Punkte (Zeitaufwand insgesamt ca. 120 Arbeitsstunden)

Lecture notes

Pro Kurseinheit (Woche) sind ca. 30–40 Seiten zu lesen. Für einzelne Kurseinheiten müssen Sie etwas mehr lesen (zwei Buchkapitel, ca. 60–80 Seiten insgesamt). Es lohnt sich also, bereits von Anfang des Kurses an ein wenig «auf Vorrat» zu lesen.

Weitere Lehrmaterialien finden Sie auf: http://www.ib.ethz.ch/teaching/pwgrundlagen
This course provides an introduction to psychological research and modelling, focusing on cognitive psychology and the psychological

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a

ECTS

Prerequisites / notice

860-0023-00L International Environmental Politics

International Environmental Politics

Abstract

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and

Objective

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a

Content

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and

860-0023-00L International Environmental Politics

International Environmental Politics

Abstract

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and

Objective

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a

Content

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and

860-0023-00L International Environmental Politics

International Environmental Politics

Abstract

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and

Objective

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a

Content

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-2120-00L</td>
<td>Consumer Behaviour I</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Siegrist, A. Bearth, A. Berthold</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individuial determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individuial determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior</td>
<td></td>
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</tr>
</tbody>
</table>

| 701-0785-00L | Introduction to Science Communication (University of W Zürich) | 4 credits | 2V | M. Schäfer |
|Abstract    | The course gives an introductory overview in research questions, theoretical perspectives and empirical results of science communication and environmental communication. They will be illustrated by concrete examples and via lectures from external guests. |
|Objective   | Goals: Learning to understand structures and processes of environmental and science communication, becoming more sensitive for problems of science public relations, getting an insight into public debates about environmental issues. Methods: invitation of media practitioners and experts, discussions, lectures on key theoretical concepts of communication. Topics: Concrete communication instruments like media conferences, theoretical perspectives of public relations, basic principles and examples of information campaigns, environment and science as media topics, functions and structures of science communication, relations between science, media and politics. |

| Content    | I. Introduction  
|            | - Topics: Environment, Science, Risks, Media  
|            | - Forms, Functions, Effects of Public and Mass Communication  
|            | II. Stakeholders and their Public Relations Efforts  
|            | - Public Relations and Science PR: Theoretical Perspectives, Instruments  
|            | III. Science and Environmental Issues in the Media  
|            | - Forms and Functions of Science Journalism  
|            | - Problems of Selection, Interpretation, Quality  
|            | - Media Content Analysis  
|            | - Online Communication  
|            | IV. Uses and Effects of Science and Environmental Communication  
|            | - Extent of Media Use  
|            | - Effects on Knowledge, Risk Perceptions, Environmental Attitudes  
|            | - Effects on Science itself  

| Lecture notes | Literature and powerpoint presentations will be provided on the OLAT platform. |

| Prerequisites / notice | Die Vorlesung wendet sich auch an Studierende der Publizistikwissenschaft der Universität Zürich. 

### Module Humanities

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0703-00L</td>
<td>Environmental Ethics</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Deplazes Zemp</td>
</tr>
<tr>
<td>Abstract</td>
<td>The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.</td>
<td></td>
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</tr>
</tbody>
</table>
|Content     | - Introduction to general and applied ethics.  
|            | - Overview and discussion of ethical theories relevant to address environmental challenges.  
|            | - Familiarisation with various basic standpoint within environmental ethics.  
|            | - Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.  
|            | - Practicing of newly acquired knowledge in smaller exercises. |
| Lecture notes | Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists. |
Literature
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O'Neill et al., Environmental Values, 2008

Generel introductions:
- Marcus Düwell et al. (Hrg.), Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006
- Johann S. Ach et al. (Hrg.), Grundkurs Ethik 1. Grundlagen, Paderborn (mentis) 2008

Prerequisites / notice
The procedure for accumulating CP will be explained at the start of term. We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

►►► Creditable Language Courses
Of the listed English language courses, a maximum of 2 CP can be credited.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0832-10L</td>
<td>Advanced English for Academic Purposes (C1-C2)</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Course fees:

Registration dates:

Abstract
This course is designed for Bachelor’s and Master’s students from all disciplines who wish to improve their English from C1 towards C2 level and train their language skills at mastery level. Selected academic English features are included to add value to the course to meet standard entrance requirements by leading universities and colleges worldwide.

Objective
Participants should already have reached C1 level (advanced) as defined in the Common European Framework of Reference for Languages (CEFR). The course is also open to participants whose level is above C1.

The course aims to train and develop linguistic skills at mastery level, with a focus on formal and informal academic lexis, on listening and oral communication skills, and on increasing fluency, accuracy, and complexity of spoken language. Students will work on writing well-structured descriptive texts and argumentative essays, with the aim of fulfilling the language requirements for study at an English-speaking university or following university Master’s courses held in English.

►► High recommended Natural Science and Technical Electives
►► For the Specialization in Biogeochemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0225-00L</td>
<td>Organic Chemistry</td>
<td>W</td>
<td>2 credits</td>
<td>2V+1U</td>
<td>K. McNeill</td>
</tr>
</tbody>
</table>

Abstract
Basics of Organic Chemistry. Reaction mechanisms in organic chemistry (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution and NMR spectroscopy)

Objective
This course builds on General Chemistry I and II. The students will learn the basic reaction mechanisms in organic chemistry. They will be able to understand and formulate simple organic reactions.

Content
Descriptive chemistry of functional groups (alkyl halides, alkenes, aromatic systems, carbonyls).
Reaction mechanisms (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution).
NMR spectroscopy.

Literature
Carsten Schmuck, Basisbuch Organische Chemie, Pearson
Der Stoff der Basischemie wird vorausgesetzt.

<table>
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<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-0100-00L</td>
<td>Biochemistry</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>C. Frei</td>
</tr>
</tbody>
</table>

Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo. Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes. Students are able to understand - the structure and function of biological macromolecules - thermodynamic and mechanistic basics of relevant metabolic processes

Objective
Students are able to understand - the structure and function of biological macromolecules - the kinetic bases of enzyme reactions

Content
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry Structure and function of proteins Carbohydrates Lipids an biological membranes Enzymes and enzyme kinetics Catalytic strategies Metabolism: Basic concepts and design. Repetition of basic thermodynamics Glycolysis, fermentation The citric acid cycle Oxidative phosphorylation Fatty acid metabolism

Lecture notes
Horton et al. (Pearson) serves as lecture notes.

Prerequisites / notice
Basic knowledge in biology and chemistry is a prerequisite.
Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

For the Specialization in Human-Environment Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5</td>
<td>2+1U</td>
<td>L. Meier</td>
</tr>
<tr>
<td>Abstract</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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</tr>
<tr>
<td>Content</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.</td>
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</tbody>
</table>

| 401-0649-00L   | Applied Statistical Regression              | W    | 5    | 2+1U  | M. Dettling |
| Abstract       | This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis. |
| Objective      | The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling. |
| Content        | The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies. |
| Lecture notes  | A script will be available. |
| Literature     | Faraway (2005): Linear Models with R |
|                | Faraway (2006): Extending the Linear Model with R |
|                | Draper & Smith (1998): Applied Regression Analysis |
|                | Fox (2008): Applied Regression Analysis and GLMs |
|                | Montgomery et al. (2005): Introduction to Linear Regression Analysis |
| Prerequisites / notice | The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held. |

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<td></td>
<td>Negotiation</td>
<td>not assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>

For the Specialization in Environmental Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course offers an introduction into the structure and function of the human body, and how these are interlinked with one another. Focusing on physiology, the visualization of anatomy is supported by 3D-animation, Computed Tomography and Magnetic Resonance imaging.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
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</tr>
</tbody>
</table>
| Content          | - The Human Body: nomenclature, orientations, tissues  
|                  | - Musculoskeletal system, Muscle contraction  
|                  | - Blood vessels, Heart, Circulation  
|                  | - Blood, Immune system  
|                  | - Respiratory system  
|                  | - Acid-Base-Homeostasis |
| Literature       | Lecture notes and handouts  
|                  | Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008  
|                  | Faller A., Schuenke M. The Human Body; Thieme 2004  
|                  | Netter F. Atlas of human anatomy; Elsevier 2014 |

For the Specialization in Forest and Landscape

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0266-00L</td>
<td>Introduction to Dendrology</td>
<td>W</td>
<td>3 credits</td>
<td>3P</td>
<td>A. Rudow</td>
</tr>
<tr>
<td>Abstract</td>
<td>Woody plants are important elements of forest ecosystems and landscapes. The course gives an introduction to dendrology as well as to the identification of native tree and shrub species. It is a highly recomended course for the BSc specialization of Forest and Landscape and it provides the basic requirements for the consecutive course Woody Plants of Central Europe in the spring semester.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Knowledge of selected native tree and shrub species. Understanding of biological and ecological relations by means of in situ observation of woody plants. Differentiated view on forest ecosystems.</td>
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</tr>
<tr>
<td>Content</td>
<td>Introduction to dendrology on the basis of concrete examples. Emphasis on identification of tree and shrub species (80 frequent tree and shrub species) and on the understanding of tree structure (morphology of woody plants). The illustrating way of presentation and the relations between different scale levels (organ, individual, stand, ecosystem) provide an attractive insight into forest and landscape topics as well as into environmental biology.</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
| Literature       | Rudow, A., 2020: Dendrologie 1 - Folien (in German).  
|                  | Rudow, A., 2011: eBot Dendrologie (Betaversion). E-learning-Tool for the support of dendrology courses at ETHZ (application integrated in eBot, in German). |
| Prerequisites / notice | Half of the course will be held in form of excursions and practical training in the forest (ETH Hönggerberg). Besides that 4 half day excursions (Zurich and surroundings, on weekends, dates by arrangement). Weatherproof clothes are presupposed. The course provides the basic knowledge for the advanced course 701-0316-00L Woody plants of Central Europe (Dendrology 2) |

<table>
<thead>
<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0951-00L</td>
<td>GIS - Introduction into Geoinformation Science and Technology</td>
<td>W</td>
<td>5 credits</td>
<td>2V+3P</td>
<td>M. A. M. Niederhuber</td>
</tr>
<tr>
<td>Abstract</td>
<td>Theoretical basics and fundamental concepts of Geographic Information Science (GIS) are imparted and subsequently further elaborated with the software ArcGIS. At the end, the students will be able to independently solve basic realistic GIS problems.</td>
<td></td>
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</tr>
</tbody>
</table>
| Objective        | Students are able to  
|                  | - elucidate the theoretical and conceptional foundations of geographic information systems (GIS)  
|                  | - independently perform normal GIS work using commercial software and practical examples |
Content

The course covers the following topics:
- What is GIS? What are spatial data?
- The representation of reality by means of spatial data models: vector, raster, TIN
- The four phases of data modelling: Spatial, conceptual, logical and physical model
- Possibilities of data collection
- Transition of reference frame
- Spatial Analysis I: query and manipulation of vector data
- Spatial Analysis II: operators and functions with raster data
- Digital elevation models and derived products
- Process modelling with vector and raster data
- Presentation possibilities of spatial data

Prerequisites / notice

One Friday is reserved for a field trip or guest speaker;

Literature


Prerequisites / notice

Aufgrund der Grösse des verfügbaren EDV-Schulungsraumes ist die Teilnehmerzahl auf 50 Studierende beschränkt! Für die Übungen werden die Studierenden auf zwei, max. drei Zeitfenster aufgeteilt. Pro Zeitfenster können maximal 25 Studierende betreut werden.

Natural Science and Technical Electives

Agroecology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-0013-00L</td>
<td>World Food System</td>
<td>W</td>
<td>4 credits</td>
<td>4V</td>
<td>B. Studer, A. Beard, R. Finger, I. Herter-Aeberli, M. Loessner, M. Niu, M. Peydayesh, J. Six</td>
</tr>
</tbody>
</table>

Abstract

Knowledge about the World Food System will be provided, based on case studies along food value chains in countries with various development stages and dependent on multiple boundary conditions. This shall generate profound understanding of the associated global challenges especially food scarcity, suboptimal diet and nutrition, food quality and safety as well as effects on the environment.

Objective

Attending this course, the students will recognize the elements of the World Food System (WFS) approach and the problems it this supposed to treat. They will especially comprehend the four pillars of global food security, namely (I) food availability (including sustainable production and processing), (II) access to food (physical and monetary), (III) food use (including quality and safety as well as the impact on human health and well being) and (IV) resilience to the boundary conditions (environmental, economic and political).

Content

Case studies on certain foods of plant and animal origin serve to demonstrate the entire food value chain from the production of raw material to processed food and its consumer relevant property functions. In doing so, important corresponding aspects for developed, emerging and developing countries are demonstrated, by use of engineering as well as natural and social science approaches.

Lecture notes

Handouts and links are provided online.

Literature

Information on books and other literature references is communicated during the course.

Agroecology

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>751-1313-00L</td>
<td>Introduction to Agricultural Management</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>R. Finger</td>
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</table>

Abstract

Vermittlung von betriebswirtschaftlichen Grundlagenwissen und Analyse- und Planungsinstrumenten mit Anwendung auf Unternehmen der Agrar- und Ernährungswirtschaft

Objective

Teilnehmer des Kurses sollen am Ende der Vorlesung i) grundlegende Unternehmensentscheide strukturieren und analysieren können, ii) verschiedene Analyse- und Planungsinstrumente auf Fragestellungen der Produktionsplanung, Investition und Finanzierung an Beispielen anwenden zu können, iii) verschiedene Werkzeuge zur unternehmerischen Entscheidungsunterstützung anwenden können und iv) die Spezifika von Unternehmen in der Agrar- und Ernährungswirtschaft kennen.

Content

Die Vorlesung geht auf folgende Inhalte, mit spezifischen Anwendungen im Agrar- und Ernährungssektor ein:

- Grundlagen und Ziele unternehmerischen Entscheidens
- Kosten und Leistungsrechnung
- Produktionstheorie
- Produktionsprogrammplanung
- Investitionsplanung und Finanzierung
- Entscheidungen unter Unsicherheit und Risikomanagement

Lecture notes

Vorlesungsunterlagen werden im Laufe des Semesters zur Verfügung gestellt

Literature


Agroecology

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<th>Number</th>
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<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>E. Frossard</td>
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Abstract

The aim of this course is to present the processes controlling the uptake and transport of nutrients by the plant, the assimilation of nutrients in the plant, the effect of nutrients on crop yield and quality, the role of the soil as a source of nutrients for crops, and the basic principles of fertilization of different crop types using mineral and organic fertilizers.

Objective

At the end of the lecture, students know how mineral nutrients are taken up through roots and circulate in the plants and what their roles in plants are. They understand the importance of nutrients for yield formation and for crop product quality. They are able to propose fertilization plans adapted for field crops growing under Swiss conditions.

Content

A general introduction explains the needs of appropriately managing nutrients in plant production. Afterwards, we will study the physiology of plant nutrition (nutrient uptake by roots; nutrient transports in the plant; physiological roles of nutrients in the plant). Then the role of nutrients for yield formation and their effects on crop quality is dealt with. Finally, the bases of crop fertilization are taught (availability of nutrient in soil; N, P and K fertilization; different types of fertilizers).

Lecture notes

The slides will be distributed
Das Ziel vieler landwirtschaftlicher Managemententscheidungen, d. h., das Erhöhen der Produktivität und des Ertrages, basiert häufig auf

(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.

Adaptability and Flexibility

not assessed


assessed

N. Buchmann

assessed


not assessed

not assessed

K. Benabderrazik

not assessed

W

The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of

plant ecophysiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in

plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Reaktionen der Pflanzen auf Umweltfaktoren, z. B. Nährstoff- und Wasserangebot, Licht, etc. Daher werden in diesem Kurs der Einfluss von


Lecture notes

Handouts stehen online.

Literature


Prerequisites / notice

This course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems.

Taught competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

not assessed

Media and Digital Technologies

not assessed

Problem-solving

not assessed

Project Management

not assessed

Social Competencies

Communication

not assessed

Cooperation and Teamwork

not assessed

Customer Orientation

not assessed

Leadership and Responsibility

not assessed

Self-presentation and Social Influence

not assessed

Sensitivity to Diversity

not assessed

Negotiation

not assessed

Personal Competencies

Adaptability and Flexibility

not assessed

Creative Thinking

not assessed

Critical Thinking

not assessed

Integrity and Work Ethics

not assessed

Self-awareness and Self-reflection

not assessed

Self-direction and Self-management

not assessed

751-3700-00L Plant Ecophysiology

W

2 credits

2V

N. Buchmann, A. Walter

Abstract

The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO2 concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO2 gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data is included.

Objective

The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Content

Das Ziel vieler landwirtschaftlicher Managemententscheidungen, d. h., das Erhöhen der Produktivität und des Ertrages, basiert häufig auf

Reaktionen der Pflanzen auf Umweltfaktoren, z. B. Nährstoff- und Wasserangebot, Licht, etc. Daher werden in diesem Kurs der Einfluss von


Lecture notes

Handouts stehen online.

Literature


Prerequisites / notice

This course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems.

Taught competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

not assessed

Media and Digital Technologies

not assessed

Problem-solving

not assessed

Project Management

not assessed

Social Competencies

Communication

not assessed

Cooperation and Teamwork

not assessed

Customer Orientation

not assessed

Leadership and Responsibility

not assessed

Self-presentation and Social Influence

not assessed

Sensitivity to Diversity

not assessed

Negotiation

not assessed

Personal Competencies

Adaptability and Flexibility

not assessed

Creative Thinking

not assessed

Critical Thinking

not assessed

Integrity and Work Ethics

not assessed

Self-awareness and Self-reflection

not assessed

Self-direction and Self-management

not assessed

751-5003-00L Sustainable Agroecosystems II

W

2 credits

2V

K. Benabderrazik, J. Six

Abstract

This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Objective

(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.

(2) Learn and experiment on methods for field and laboratory investigations in agroecology.

(3) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective of a food system stakeholder.

(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content

The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) on both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management).

The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholders in the food system in order to support a sustainable transformation.

Literature


Prerequisites / notice

Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.
<table>
<thead>
<tr>
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<td>Problem-solving</td>
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<td>Cooperation and Teamwork</td>
<td>Sensitivity to Diversity</td>
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<td>Critical Thinking</td>
<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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751-5005-00L Agroecology (HS) W 2 credits 2G M. Sonnevelt, N. Buchmann

In Spring Semester a related course (Agroecology FS) will be offered. The course Agroecology (HS) is not a prerequisite, the courses can be taken independently of each other.

Abstract
Agroecology is a discipline, an agricultural practice, and a political-social movement. Students will attend lectures in which experts from different fields reflect on agroecology and its principles. Based on these inputs, students will discuss among each other about the role of agroecology to support sustainable ag and food systems.

Objective
Students know the thirteen principles of the High Level Panel of Experts (HLPE) of the Committee on World Food Security as well as the ten elements of agroecology as suggested by FAO and can critically reflect on the important properties as well as benefits and trade-offs of agroecological systems and approaches. Students will be able to transfer their disciplinary and interdisciplinary knowledge about the thirteen principles as guiding principles for policymakers, practitioners and other stakeholders across the food system in planning, managing and evaluating agroecological transitions. Students engage in a lively and critical debate and learn about scientific contributions to agroecology. Based on the knowledge gained, students are able to form a personal opinion on the role of agroecology as well as to reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

Content
The course is designed as a combination of a series of five public lectures/webinars on “Agroecology in the transition to sustainable food systems” delivered by national and international scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a debate format. The public lectures bring different perspectives to the discussion and are intended to fuel the students debates in the second part of each course. Each of these debates revisits one of the thirteen principles of agroecology. Each debate which is organised in form of a role play will involve different groups of students taking on roles of various food system actors. All groups will synthesize their discussions in a short report.

751-7501-00L Animal Housing and Behaviour W 1 credit 1V S. Goumon

Abstract
The overall goal of this course is to provide general knowledge about the behaviour, housing and welfare of domestic animals.

Objective
Students will:
- Understand the basis of animal behaviour and how it is measured
- Acquire knowledge of housing systems and management of domestic animals
- Get a concept of animal needs and welfare

Content
CONTENTS
BEHAVIOR
- Fundamentals of animal behavior: mechanisms, development, function and evolution
- Overview of the natural behavioural repertoire of various livestock species and the resulting needs
- Insights in behavioural studies

ANIMAL HUSBANDRY
- Fundamentals of animal husbandry
- Insight in animal transportation and slaughter

BEHAVIOR vs. ANIMAL HUSBANDRY
- Adapt the husbandry practices to livestock-specific needs
- Recurrent problems in livestock management
- Concept of animal welfare

PERFORMANCE ASSESSMENT: 1 written report (20%) + 1 final examination (80% of grade)

Lecture notes
Handouts/scripts are provided by the lecturers.

Literature
Specific literature recommendations will be provided by the lecturers as appropriate

Prerequisites / notice
This lecture is part of the Agricultural Sciences Bachelor (3rd Semester) Being able to attend the exam on the only possible date of the 3.11.2022 from 14-16h is a prerequisite.
Taught competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

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Biomedicine

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<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Wyss</td>
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<td>one another. Focusing on physiology, the visualization</td>
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<td>Tomography and Magnetic Resonance imaging.</td>
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<td>- The Human Body: nomenclature, orientations, tissues</td>
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<td>- Acid-Base-Homeostasis</td>
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<td>Silbernagl S., Despopoulos A. Color Atlas of Physiology;</td>
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<td>Thieme 2008</td>
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<td>Faller A., Schuenke M. The Human Body; Thieme 2004</td>
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<td>Netter F. Atlas of human anatomy; Elsevier 2014</td>
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<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
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<td>- Introduction and historical background</td>
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<td>- Innate and adaptive immunity, Cells and organs of the</td>
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<td>- B cells and antibodies</td>
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<td>- Generation of diversity</td>
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<td>- Antigen presentation and Major Histoincompatibility (MHC)</td>
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<td>- Thymus and T cell selection</td>
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<td>- Autoimmunity</td>
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<td>- Cytotoxic T cells and NK cells</td>
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<td>- Th1 and Th2 cells, regulatory T cells</td>
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<tr>
<td></td>
<td>Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020</td>
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<td>For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a &quot;Sessionsprüfung&quot;. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.</td>
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</table>
This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

The course is divided into two parts. The lectures on micronutrients are given by Prof. Wolfrum. Prof. Zimmermann discusses the micronutrients, including fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. Prof. Wolfrum introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeoressor are emphasized.

**Lecture notes**
There is no script. Powerpoint presentations will be made available.

**Literature**
- Elmada I & Leitzmann C: Ernährung des Menschen. UTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004

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**Soil Sciences**

<table>
<thead>
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<td>Soil and Water Chemistry</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. Kretzschmar, D. I. Christl, L. Winkel</td>
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</tbody>
</table>

**Abstract**
This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.

**Objective**
1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants.
2. Quantitative applications of chemical equilibria to processes in natural systems.

**Content**
Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

**Lecture notes**
Lecture slides on Moodle
- Chapters 1, 3, 4, 6, 7 and 11 in Sigl/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016.

**Prerequisites / notice**
The lecture courses Pedosphere and Hydrosphere are highly recommended.

**Taught competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Techniques and Technologies

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<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>701-0535-00L</td>
<td>Environmental Soil Physics/Vadose Zone Hydrology</td>
<td>W</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Carminati, P. U. Lehmann Grunder</td>
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**Abstract**
The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

**Objective**
- Students are able to
  - characterize porous media at different scales
  - parameterize structural, flow and transport properties of partially-saturated porous media
  - quantify driving forces and resulting fluxes of water, solute, and heat in soils

---

Data: 18.08.2022 12:39
Autumn Semester 2022
Page 2145 of 2345
Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid, liquid and gaseous phases; soil water content; soil texture; particle size distributions;

Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure

Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab

Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, capillary rise); units and calculations and measurement of equilibrium soil water potential components

Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab

Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)

Week 7: Unsaturated water flow in soils - unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8: Numerical solution of Richards equation – using Hydrus1D for simulation of unsaturated flow; choosing class project

Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow

Week 10: Root water uptake and transpiration

Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 12: Summary of lectures; solution of old exam

Week 13: Written semester-end exam

Week 14: Short presentations of Hydrus class projects; discussion of written exam

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

Einführung in die Geologie der Schweiz.


Übungen zum Gesteinsbestimmen und Lesen von geologischen, tektonischen und geotechnischen Karten, einfache Konstruktionen.

The course is based on Press & Siever book Dynamic Earth by Grotzinger et al., available to ETH students via https://link.springer.com/book/10.1007/978-3-662-48342-8

This introductory course starts from a descriptions of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.


Written course documentation available under "Kursunterlagen".

The aim of these lecture is to present the processes controlling the uptake and transport of nutrients by the plant, the assimilation of nutrients in the plant, the effect of nutrients on crop yield and quality, the role of the soil as a source of nutrients for crops, and the basic principles of fertilization of different crop types using mineral and organic fertilizers.

At the end of the lecture, students know how mineral nutrients are taken up through roots and circulate in the plants and what their roles in plants are. They understand the importance of nutrients for yield formation and for crop product quality. They are able to propose fertilization plans adapted for field crops growing under Swiss conditions.

A general introduction explains the needs of appropriately managing nutrients in plant production. Afterwards, we will study the physiology of plant nutrition (nutrient uptake by roots; nutrient transports in the plant; physiological roles of nutrients in the plant). Then the role of nutrients for yield formation and their effects on crop quality is dealt with. Finally, the bases of crop fertilization are taught (availability of nutrient in soil; N, P and K fertilization; different types of fertilizers).
The slides will be distributed

Schubert S 2006 Pflanzenernährung Grundwissen Bachelor Ulmer UTB
Richner W. & Sinaj S., 2017. Grundlagen für die Düngung landwirtschaftlicher Kulturen in der Schweiz (GRUD 2017). Agrarforschung Schweiz 8 (6), Spezialpublikation,
Bergmann, W. 1988; Ernährungsstörungen bei Kulturpflanzen.
http://www.tll.de/visuplant/vp_idx.htm

Subject-specific Competencies

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<th>Concepts and Theories</th>
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Method-specific Competencies

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Social Competencies

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Personal Competencies

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<td>Self-direction and Self-management</td>
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Methods of Statistical Data Analysis

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<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0625-01L</td>
<td>W</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
<tr>
<td>Abstract</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<tr>
<td>Content</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.</td>
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<tr>
<td>401-0649-00L</td>
<td>W</td>
<td>Applied Statistical Regression</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<tr>
<td>Objective</td>
<td>The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.</td>
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<tr>
<td>Content</td>
<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies. The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.</td>
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<tr>
<td>Lecture notes</td>
<td>A script will be available.</td>
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<tr>
<td>Literature</td>
<td>Faraway (2005): Linear Models with R</td>
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<tr>
<td>Faraway (2006): Extending the Linear Model with R</td>
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<tr>
<td>Draper &amp; Smith (1998): Applied Regression Analysis</td>
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<tr>
<td>Fox (2008): Applied Regression Analysis and GLMs</td>
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<tr>
<td>Montgomery et al. (2006): Introduction to Linear Regression Analysis</td>
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</table>

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
Ecology and Conservation Biology

<table>
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<tr>
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<td>701-0305-00L</td>
<td>Vertebrate Ecology</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>K. Bollmann, U. Kormann</td>
</tr>
</tbody>
</table>

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**Using R for Data Analysis and Graphics (Part I)**

**W 1.5 credits 1G M. Mächler**

**Abstract**

The course provides the first part of an introduction to the statistical software R for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

**Objective**

The students will be able to use the software R for simple data analysis and graphics.

**Content**

- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

**Lecture notes**

An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

The course resources will be provided via the Moodle web learning platform.

As from FS 2019, subscribing via Mystudies should *automatically* make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15518

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**Using R for Data Analysis and Graphics (Part II)**

**W 1.5 credits 1G M. Mächler**

**Abstract**

The course provides the second part of an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

**Objective**

Note: This part builds on "Using R... (Part I)", but can be taken independently if the basics of R are already known.

**Content**

The course provides the second part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options;
- Extending basic R: packages

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

**Lecture notes**

An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Basic knowledge of R equivalent to "Using R... (part I)" (= 401-6215-00L) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform.

As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15522

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**Vertebrate Ecology**

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<td>2G</td>
<td>K. Bollmann, U. Kormann</td>
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</table>
Abstract
The course covers the ecology and conservation biology of birds and mammals. Important concepts from physiology, behavioural ecology, population biology, biogeography and community ecology will be linked to applications in conservation and management. A worldwide perspective will be complemented by a focus on the Central European fauna and its dynamics.

Objective
The students are familiar with important topics in animal ecology of vertebrates, with an emphasis on birds and mammals. They are able to link theoretical concepts with ecological phenomena and view them against an evolutionary backdrop. They can thus appraise applied aspects of the conservation and the use of animal populations, such as the influence of food availability on habitat use of birds and mammals, relationships between predators and prey species, or of herbivores on vegetation, and the effects of hunting and landscape change on animal populations. Students understand the biogeographical characteristics of the Central European vertebrate fauna and its temporal and spatial dynamics.

Content
The course deals with a number of main topics that include feeding and resource use, spatial behaviour and migrations, reproduction, population dynamics, competition and predation, parasites and diseases, biodiversity and distributions, and dynamics of the Central European fauna. There is an emphasis on linking theory with management issues in conservation and management of wildlife populations. During the first half of the course, examples will be drawn worldwide whereas during the second half, the course will focus more strongly on the European fauna, particularly of the Alpine region. Although the course is not designed to teach natural history of the native species, examples will cover much of the taxonomic breadth of the European fauna.

The course includes a field excursion.

Program (KB: Kurt Bollmann, N/A: 2nd lecturer):

1. Feeding I: Food, metabolism (KB)
2. Feeding II: Energetic needs, foraging, digestion (KB)
3. Distribution and habitat use, bird migration (self-study)
4. Reproduction, litter and clutch size, breeding systems (N/A)
5. Population dynamics (KB)
6. Predation, predator-prey-cycles (KB)
7. Competition (N/A), Parasitism and diseases (self-study)
8. Biogeography of central European birds and mammals (KB)
9. Herbivores as landscape engineers (self-study)
10. Threats to birds and mammals, incl. climate change (KB)
11. Conservation biology of selected species (N/A)
12. Exploitation of mammals and birds + pilot test (KB)

Lecture notes
Lecture notes will be available for CHF 15.

Literature
Some books relevant to the course are (optional reading):
- Suter, W. 2017. Ökologie der Wirbeltiere. Vögel und Säugetiere. UTB/Haupt, Bern. This book is based on the course. It is in German.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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701-0405-00L Fresh Water: Concepts and Methods for Sustainable Management

Abstract
In this course, we will discuss inland water ecosystems, their basic ecological characteristics, as well as their anthropogenic influences and changes. Case studies are used to discuss concepts and methods for sustainable management. The case studies are mostly from Switzerland and refer to the Water Protection Act and the Swiss Biodiversity Strategy.

Objective
- basics concerning the functioning of the most important freshwater ecosystems
- basics of the sustainable management of aquatic ecosystems
- application of these principles with case studies
- critical analyses, organization of discussion groups

Content
1) 1st lesson: Student working groups, working method
2) Biodiversity in floodplains
3) Revitalization of rivers and lakes
4) Floodplain management and revitalisation
5) Protection of watercourses and lakes
6) River widenings and ramps
7) Restoration of the sediment dynamics
8) Changing discharge and temperature regimes in rivers and lakes
9) Planning and operation of pumped storage power plants
10) Water and health, including climate change
11) Fish migration in multi-purpose watercourses
12) Mine protection
13) Final Evaluation/ Feedback

Lecture notes
Themenspezifische Unterlagen (Vorlesung Dozierende, Literatur) werden verteilt und auf Moodle zugänglich gemacht (Link folgt).
Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures. 

Erreichbarkeit mit Tram 14 bis Triemli, danach PTT-Bus 220 oder 350 bis Birmensdorf Sternen/WSL, oder mit S9 bis Birmensdorf SBB und mit PTT-Bus eine Station in Richtung Zürich bis Birmensdorf Sternen/WSL.
Objective
The students are able to
- name and recognize the most important classes of environmentally relevant anthropogenic chemicals and identify chemical moieties governing their fate processes.
- explain, on the basis of physical-chemical foundations, the most important processes (i.e., partitioning and substitution and elimination reactions) which determine the environmental behavior of organic pollutants.
- identify, on the basis of chemical structure, the processes relevant for the environmental behavior of a compound.
- critically evaluate published work and data.

Content
- Overview of the most important classes of environmental organic pollutants
- Molecular interactions that determine the partitioning behavior (adsorption and absorption processes) of organic compounds between different environmental compartments (gas, liquid, solid)
- Physical-chemical properties (vapor pressure, aqueous solubility, air-water partition constant, organic solvent-water partition constants, etc) and partitioning behavior of organic compounds between environmentally relevant phases (air, aerosols, soil, water, biota)
- Chemical transformation reactions of organic pollutants in aquatic and in terrestrial environments (hydrolysis, elimination, addition)

Lecture notes
Script will be distributed

Literature

Prerequisites / notice
Die Lehrveranstaltung richtet sich nicht nur an jene Studierenden, welche sich später chemisch vertiefen wollen, sondern ausdrücklich auch an alle jene, welche sich mit der Problematik von organischen Schadstoffen in der Umwelt vertraut machen wollen, um dieses Wissen in anderen Vertiefungen anzuwenden

701-0225-00L Organic Chemistry W 2 credits 2V+1U K. McNeill

Abstract
Basics of Organic Chemistry. Reaction mechanisms in organic chemistry (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution and NMR spectroscopy)

Objective
This course builds on General Chemistry I and II. The students will learn the basic reaction mechanisms in organic chemistry. They will be able to understand and formulate simple organic reactions.

Content
Descriptive chemistry of functional groups (alkyl halides, alkenes, aromatic systems, carbonyls). Reaction mechanisms (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution). NMR spectroscopy.

Literature

529-0051-00L Analytical Chemistry I W 3 credits 3G D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications.

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.
- UV/VIS spectroscopy: Basics, interpretation of electron spectra. Circular dichroism (CD) and optical rotation dispersion (ORD).

Lecture notes
Script will be for the production price

Literature

Prerequisites / notice
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

Environmental Physics

Number
Title
Type
ECTS
Hours
Lecturers
701-0479-00L Environmental Fluid Dynamics W 3 credits 2G H. Wernli, M. Röthlisberger

Abstract
This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.

Objective
Students are able
- to name the bases, concepts and methods of environmental fluid dynamics.
- to understand and discuss the components of the basic physical equations in fluid dynamics
- to apply basic mathematical equations to simple problems of environmental fluid dynamics.
- the competencies of process understanding and system understanding are taught, applied and examined.

Content
Basic physical terminology and mathematical laws:
- Continuum hypothesis, forces, constitutive laws, state equations and basic principles of thermodynamics, kinematics, laws of mass and momentum on rotating earth.
- Concepts and illustrative flow systems: vorticity dynamics, boundary layers, instability, turbulence - with respect to environmental fluid systems.
- Scale analysis: dimensions variables and dynamical similarity, simplification of the fluid system, e.g. shallow water assumption, geostrophic flow.
- Waves in environmental fluid systems.

Lecture notes
In english language

Literature
Will be presented in class. See also: web-site.
**Taught competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

**Content**

**Hydraulics I**
- Properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids vs. real fluids, boundary layer, pipe flow, open channel flow, flow measurements, demonstration experiments in the lecture hall.

**Literature**
- Bollrich, Technische Hydromechanik 1, Verlag Bauwesen, Berlin

**Groundwater I**
- Properties of porous and fractured media, Darcy's law, flow equation, stream functions, interpretation of pumping tests, transport processes, transport equation, analytical solutions for transport, numerical methods: finite differences method, aquifers remediation, case studies.

**Literature**
- W. Kinzelbach, R. Rausch, Grundwassermodellierung, Gebrüder Bornträger, Stuttgart, 1995

**Cryosphere**
- The course introduces the different components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.

**Literature**

Further literature will be indicated during the lecture.
Environmental Planning

101-0515-00 Projektmanagement and 103-0313-00 Raum- und Landschaftsentwicklung are prerequisites for the Master's degree programme in Spatial Development and Infrastructure Systems and should be successfully completed in the Bachelor's degree if possible.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0009-00L</td>
<td>Tackling Environmental Problems III</td>
<td>W</td>
<td>3 credits</td>
<td>4U</td>
<td>M. Mader, C. E. Pohl</td>
</tr>
<tr>
<td>701-0901-01L</td>
<td>ETH Week 2022: Urban Futures</td>
<td>W</td>
<td>1 credit</td>
<td>3S</td>
<td>F. Rittiner, S. Brusoni, R. Knutti, S. Menz, A. Vaterlaus</td>
</tr>
</tbody>
</table>

---

**Taught competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

**Social Competencies**

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

---

**Objective**

ETH Week is an innovative one-week course designed to foster critical thinking and creative learning. Students from all departments as well as professors and external experts will work together in interdisciplinary teams. They will develop interventions that could play a role in solving some of our most pressing global challenges. In 2022, ETH Week will focus on the topic of urban development.

- Domain-specific knowledge: Students have immersed knowledge about a certain complex, societal topic which will be selected every year. They understand the complex system context of the current topic, by comprehending its scientific, technical, political, social, ecological and economic perspectives.

- Analytical skills: The ETH Week participants are able to structure complex problems systematically using selected methods. They are able to acquire further knowledge and critically analyse the knowledge in interdisciplinary groups and with experts and the help of team tutors.

- Design skills: The students are able to use their knowledge and skills to develop concrete approaches for problem-solving and decision making to a selected problem statement, critically reflect on these approaches, assess their feasibility, to transfer them into a concrete form (physical model, prototypes, strategy paper, etc.) and to present this work in a creative way (role-plays, videos, exhibitions, etc.).

- Self-competence: The students are able to plan their work effectively, efficiently and autonomously. By considering approaches from different disciplines they are able to make a judgment and form a personal opinion. In exchange with non-academic partners from business, politics, administration, non-governmental organisations and media they are able to communicate appropriately, present their results professionally and creatively and convince a critical audience.

- Social competence: The students are able to work in multidisciplinary teams, i.e. they can reflect critically on their own discipline, debate with students from other disciplines and experts in a critical-constructive and respectful way and can relate their own positions to different intellectual approaches. They can assess how far they are able to actively make a contribution to society by using their personal and professional talents and skills as "Change Agents".

- Remote collaboration competence: The students work in a hybrid setting blending physical and virtual communication and collaboration methods and tools. They experience the potential and limitations of remote collaboration.
The week is mainly about problem-solving and design thinking applied to the complex world of health and well-being. During ETH Week students will have the opportunity to work in small interdisciplinary groups, allowing them to critically analyse both their own approaches and those of other disciplines, and to integrate these into their work.

While deepening their knowledge about sustainable urban development, students will be introduced to various methods and tools for generating creative ideas and understanding how different people are affected by each part of the system. In addition to lectures and literature, students will acquire knowledge via excursions into the real world, empirical observations, and conversations with researchers and experts.

A key attribute of ETH Week is that students are expected to find their own problems, rather than just solve the problem that has been handed to them.

Therefore, the first three days of the week will concentrate on identifying a problem the individual teams will work on, while the last two days are focused on generating solutions and communicating the team’s ideas.

No prerequisites. Programme is open to Bachelor and Masters from all ETH Departments. All students must apply through a competitive application process at www.ethz.ch/ethweek. Participation is subject to successful selection through this competitive process.

**Course Content**

- Theoretical basics and fundamental concepts of Geographic Information Science (GIS) are imparted and subsequently further elaborated with the software ArcGIS.
- At the end, the students will be able to independently solve basic realistic GIS problems.

**Objective**

Students are able to:
- elucidate the theoretical and conceptional foundations of geographic information systems (GIS)
- independently perform normal GIS work using commercial software and practical examples

**Content**

The course covers the following topics:
- What is GIS? What are spatial data?
- The representation of reality by means of spatial data models: vector, raster, TIN
- The four phases of data modelling: Spatial, conceptual, logical and physical model
- Possibilities of data collection
- Transition of reference frame
- Spatial Analysis I: query and manipulation of vector data
- Spatial Analysis II: operators and functions with raster data
- Digital elevation models and derived products
- Process modelling with vector and raster data
- Presentation possibilities of spatial data

One Friday is reserved for a field trip or guest speaker;

- Presentation possibilities of spatial data
- Process modelling with vector and raster data
- Transition of reference frame
- Digital elevation models and derived products
- Possibilities of data collection
- Possibilities of data collection

**Literature**


**Prerequisites / notice**

- Number of participants limited to 75.
- Waiting list will be deleted 07.10.2022.

**701-0951-00L GIS - Introduction into Geoinformation Science and Technology**

**701-0967-00L Project Development in Renewable Energies**
Literature

- Mit einer grünen Anlage schwarze Zahlen schreiben Link
- UNEP: Global Trends in Renewable Energy Investments
- Energiestrategie 2050 Faktenblätter des Bundes (PDF):
  https://www.uvek.admin.ch/uvek/de/home/energie/energiestrategie-2050.html
- Wind Technologies Market Report, Lawrence Berkeley National Laboratory
  https://emp.lbl.gov/wind-technologies-market-report
- IEE PVPS: TRENDS IN PHOTOVOLTAIC APPLICATIONS
  http://www.iea-pvps.org
- Bundesamt für Energie: Perspektiven für die Grosswasserkraft in der Schweiz
- Windenergie-Report Deutschland
- Ernest & Young Renewable Energy Index, (Magazin)
- Bundesamt für Energie: Perspektiven für die Grosswasserkraft in der Schweiz
- Verbrauchsabhängiges Abrechnungsmodell Energie und Wasser,
  VEWA-Modell Bund
  https://www.newsadmin.ch/newsadmin/message/attachments/48829.pdf
- Leitfaden zur Beglaubigung von Anlagendaten der Pronovo
  https://pronovo.ch/download/leitfaden-zur-beglaubigung-von-anlage-und-produktionsdaten/?wpdmdl=7339
- Unterragen Kleinwasserkraft-Projekte
  https://www.bfe.admin.ch/bfe/de/home/versorgung/erneuerbare-energien/wasserkraft/kleinwasserkraft.html
- Unterragen Windkraft-Projekte
  https://www.bfe.admin.ch/bfe/de/home/versorgung/erneuerbare-energien/windenergie.html
- Fundamentals of public and collective transport, in its different forms.
- Categorization of performance dimensions of public transport systems, and their implications to their design and operations.
- Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.
- Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspective and stakeholders.
- At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.
- Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings
- Vehicles: Classification, design and suitability for different goals
- Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.
- Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity
- Slides, in English, are made available some days before each lecture.
- Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

101-0415-01L Public Transport and Railways

Abstract

Fundamentals of public and collective transport, in its different forms.
Categorization of performance dimensions of public transport systems, and their implications to their design and operations.

Objective

Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.
Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspective and stakeholders.
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.

Content

Fundamentals: Infrastructures and vehicle technologies of public transport systems; interaction between track and vehicles; passengers and goods as infrastructure users; management and financing of networks.
Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings
Vehicles: Classification, design and suitability for different goals
Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.
Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity

Lecture notes

- Slides, in English, are made available some days before each lecture.
- Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

103-0313-00L Spatial Planning and Landscape Development

Abstract

Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.
Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspective and stakeholders.
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.

Content

Fundamentals: Infrastructures and vehicle technologies of public transport systems; interaction between track and vehicles; passengers and goods as infrastructure users; management and financing of networks.
Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings
Vehicles: Classification, design and suitability for different goals
Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.
Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity

Lecture notes

- Slides, in English, are made available some days before each lecture.
- Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung
Abstract

The lecture introduces into the main-features of spatial planning. Attended will be the subjects planning as a national responsibility, instruments of spatial planning, techniques for problem solving in spatial planning and the Swiss concept for national planning. The lecture is complemented with in-depth topics and international examples.

Objective

Die Studierenden kennen die Grundzüge der Raumplanung, ihre wichtigen Instrumente und Problemlosungsverfahren. Sie können das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Übungsaufgaben umsetzen.

- Grundzüge der Raumplanung und ihre wichtigsten Instrumente kennenlernen
- Erarbeiten der Fähigkeit, räumliche Probleme zu erkennen und Problemlosungsverfahren auf diese anzuwenden
- Planung und Landmanagement als interaktives Problemlosungsverfahren kennenlernen und anwenden
- Verstehen der mit Fläche und Boden verbundenen Potentiale, Nutzungen und Prozesse
- Das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Fallbeispielen umsetzen können

Content

Die Vorlesung deckt die Grundlagen der (Schweizerischen) Raumplanung und Landschaftsentwicklung ab:

- Was ist Raumplanung (Begriffe)
- Prinzipien der Raumplanung
- Die Raumplanung als staatliche Aufgabe - Raumordnungspolitik
- Instrumente der Raumplanung auf den Planungsebenen (u.a. Sachpläne und Konzepte, Richtplanung, Nutzungsplanung, Sondernutzungsplanung, Landumlegungsverfahren)
- Problemlosungsverfahren in der Raumplanung - systemtechnisches Vorgehen
- Das schweizerische Raumordnungskonzept

Die Schwerpunkte der Vorlesung liegen auf der Erläuterung der Raumplanung als Problemlosungsverfahren. Das dabei vermittelte theoretische Wissen wird direkt an konkreten, praxisorientierten Übungsaufgaben umgesetzt. Im Rahmen der Übung wird das Projektgebiet während einer Exkursion besucht.

Lecture notes

Prof. Dr. W.A. Schmid et al. (2006, Stand 2017): Raumplanung GZ - Eine Einführung für Ingenieurstudierende. IRL-PLUS, ETHZ

- Handouts of the lectures
- Exercises

Download: http://www.plus.ethz.ch/de/studium/vorlesungen/bsc/spatial_planning_and LANDSchaft_envelopment.html

101-0515-00L Project Management W 2 credits 2G C. G. C. Marx

Abstract

The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

Objective

Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company wide success.

Content

The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project.

Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Lecture notes

No. The lecture slides and other additional material will be available for download from Moodle a week before each class.

► Specialization in an Environmental System

►► Atmosphere and Climate

The following courses are highly recommended as preparation for the Specialization in Atmosphere and Climate:

701-0106-00L Mathematik V: Angewandte Vertiefung von Mathematik I - III (Spring semester)
402-0048-00L Fortgeschrittene Physik für Umwelt- und ErdwissenschaftlerInnen (Spring semester)

These courses should be successfully completed during the second year.

Number Title Type ECTS Hours Lecturers

701-0459-00L Seminar for Bachelor Students: Atmosphere and Climate W 3 credits 2S R. Knutti, C. Brunner, O. Stebler

Abstract

In this seminar all students in the realm of atmospheric and climate science from D-ERDW and D-USYS convene to train presentation techniques (talks, posters) by means of classic and modern scientific articles.

Objective

In this seminar, students learn how to read scientific publications and how to transfer the scientific knowledge to a broader audience by means of oral and poster presentations. Students also get insight into the different research areas at the Institute for Atmospheric and Climate Science.

Content

1st week: course organisation and presentation of the institute
2nd and 3rd week: introduction to oral presentation technique
week 4 to 10: students talks
11th week: introduction to poster presentation technique
12th and 13th week: poster design
14th week: concluding poster presentation

Lecture notes

Documents are offered via the course's web page.

Literature

Documents are offered via the course's web page.

Prerequisites / notice

This course can only be offered to a limited number of students, however, in any case for everybody having to attend it compulsory. We beg you to sign in to this course early.

701-0461-00L Numerical Methods in Environmental Physics W 3 credits 2G C. Schär, C. Zeman

Abstract

This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python. Ability to critically use more complex numerical models.
Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration schemes, non-linearity, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-section of Environmental Science.

Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not necessary, a Python introduction is provided). Example programs and graphics tools are supplied.

Lecture notes and slides from the textbook will be made available on moodle: https://moodle-ethz.ch/edu/courses/bachelor/vertiefung/numerical-methods-in-environmental-physics.html

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Literature</th>
</tr>
</thead>
</table>
| Per Web auf http://www.iac.ethz.ch/edu/courses/bachelor/vertiefung/numerical-methods-in-environmental-physics.html | List of literature is provided.

**701-0471-01L Atmospheric Chemistry**

**Abstract**

This self-study course provides an introduction to atmospheric chemistry at bachelor level. It introduces the fundamentals of gas phase reactions, the concept of solubility and reactions in aerosols and in clouds. It explains the chemical and physical processes responsible for global (e.g. stratospheric ozone depletion) as well as regional environmental problems (e.g. urban air pollution).

**Objective**

The students will understand the basics of gas phase reactions and interactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere.

Students will also acquire a good understanding of atmospheric environmental problems including air pollution, tropospheric ozone formation, stratospheric ozone destruction and the relationship between air pollution and climate change.

**Content**

- Origin and properties of the atmosphere: structure, large scale dynamics, UV radiation
- Thermodynamics and kinetics of gas phase reactions: enthalpy and free energy of reactions, rate laws, mechanisms of bimolecular and termolecular reactions.
- Tropospheric photochemistry: Photolysis reactions, photochemical O3 formation, role and budget of HOx, dry and wet deposition
- Aerosols and clouds: chemical properties, primary and secondary aerosol sources, phase transfer kinetics, solubility and hygroscopicity, N2O5 chemistry, SO2 oxidation, secondary organic aerosols
- Air quality: role of planetary boundary layer, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Stratospheric chemistry: Chapman cycle, Brewer-Dobson circulation, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
- Global aspects: global budgets of ozone, methane, CO and NOx, air quality - climate interactions

**Lecture notes and slides** from the most recent corresponding bachelor course are provided.

**Prerequisites / notice**

Basic courses in chemistry and physics are expected.

**701-0473-00L Weather Systems**

**Abstract**

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes

**Objective**

The students are able to

- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems

**Content**

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

**Lecture notes and slides**

**Literature**

Atmospheric Science, An Introductory Survey

John M. Wallace and Peter V. Hobbs, Academic Press

**Prerequisites / notice**

Basic physics

**3 credits**

**701-0475-00L Atmospheric Physics**

**Abstract**

This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.

**Objective**

Students are able to

- to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clapeyron equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to classify radiosondes with the help the thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

**Lecture notes**

Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app22.let.ethz.ch/course/view.php?id=15367

**Literature**

This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients.

Part 1: Literature search; presentation and moderation techniques.

Critical Thinking

ECTS

M. Sander

D. I. Christl

W

assessed

Schwarzenbach, R.P., P.M. Gschwend, and D.M. Imboden.

2G

The students are able to

assessed

, A. N’Guyen van Chinh

Title

Soil and Water Chemistry

Script will be distributed

Concepts and Theories

assessed

analyze

Literature

Lecture notes

Content

- name and recognize the most important classes of environmentally relevant anthropogenic chemicals and identify chemical moieties governing their fate processes.
- explain, on the basis of physical-chemical foundations, the most important processes (i.e., partitioning and substitution and elimination reactions) which determine the environmental behavior of organic pollutants.
- identify, on the basis of chemical structure, the processes relevant for the environmental behavior of a compound.
- critically evaluate published work and data.

- Overview of the most important classes of environmental organic pollutants
- Molecular interactions that determine the partitioning behavior (adsorption and absorption processes) of organic compounds between different environmental compartments (gas, liquid, solid)
- Physical-chemical properties (vapor pressure, aqueous solubility, air-water partition constant, organic solvent-water partition constants, etc) and partitioning behavior of organic compounds between environmentally relevant phases (air, aerosols, soil, water, biota)
- Chemical transformation reactions of organic pollutants in aquatic and in terrestrial environments (hydrolysis, elimination, addition)


Selected handouts will be distributed in class.

- give and receive constructive feedback.

- Analytical Competencies
- Problem-solving

- Communication

- Critical Thinking

- Self-direction and Self-management

Taught competencies

Prerequisites / notice

Biogeochemistry

The following courses are highly recommended as preparation for the Specialization in Biogeochemistry:

701-0225-00L Organic Chemistry (Autumn semester)
752-0100-00L Biochemie (Autumn semester)
752-1300-00L Introduction to Toxicology (Spring semester)

These courses should be successfully completed during the second year.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0201-00L</td>
<td>Introduction to Environmental Organic Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Sander, K. McNeill</td>
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<tr>
<td>Abstract</td>
<td>This course is an introduction to the environmental chemistry of organic molecules, focusing on equilibrium partitioning processes and non-redox reactions.</td>
<td></td>
<td></td>
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<tr>
<td>Objective</td>
<td>The students are able to</td>
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</tr>
<tr>
<td>Content</td>
<td>- name and recognize the most important classes of environmentally relevant anthropogenic chemicals and identify chemical moieties governing their fate processes.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course &quot;Soil and Water Chemistry&quot; teaches, applies and examines the competences process understanding, systems understanding, and modelling.</td>
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<tr>
<td>701-0419-01L</td>
<td>Seminar for Bachelor Students: Biogeochemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>D. I. Christl, A. N’Guyen van Chinh</td>
</tr>
<tr>
<td>Abstract</td>
<td>Current research topics are presented and discussed based on scientific literature. The students prepare a presentation with the support of an expert. Subsequently, the topics are discussed jointly by students and experts in student-moderated discussion rounds. Presentation and moderation techniques are introduced and trained in the seminar, supported by instructions for constructive feedback.</td>
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<tr>
<td>Objective</td>
<td>The seminar aims at introducing the students to current research in the field of biogeochemistry and connect them with researchers. After the seminar, students are able to</td>
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</table>
| Content | Part 1: Literature search; presentation and moderation techniques.
Part 2: Literature study; online-exchange of information; presentation and discussion moderated by students. |
| Lecture notes | Selected handouts will be distributed in class. |
| Prerequisites / notice | Deadline for enrollment is the FIRST day of the semester. Later enrollment can only be accepted in exceptional cases and under certain conditions (e.g., restricted choice of topics and dates). |
| 701-0533-00L | Soil and Water Chemistry | W | 3 credits | 2G | R. Kretzschmar, D. I. Christl, L. Winkel |
| Abstract | This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples. |
| Objective | 1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants. 
2. Quantitative applications of chemical equilibria to processes in natural systems. |

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Autumn Semester 2022

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Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid,
liquid and gaseous phases; soil water content; soil texture; particle size distributions;
Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure
Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab
Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, and capillary rise); units and calculations and measurement of equilibrium soil water potential components
Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab
Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)
Week 7: Unsaturated water flow in soils - unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow
Week 8: Numerical solution of Richards equation – using Hydrus1D for simulation of unsaturated flow; choosing class project
Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow
Week 10: Root water uptake and transpiration
Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.
Week 12: Summary of lectures; solution of old exam
Week 13: Written semester-end exam
Week 14: Short presentations of Hydrus class projects; discussion of written exam

Human-Environment Systems

These courses should be successfully completed during the second year.

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
701-0658-00L | Seminar for Bachelor Students: Human Environment Systems | O | 3 credits | 2S | J. W. McCaughey, A. Berthold, D. N. Bresch, R. Garrett

Abstract
Analysis and presentation of research papers from the involved chairs, relating to topics from human-environment systems.

Objective
The students learn to read, understand, summarize and present current research papers related to human-environment systems. Furthermore, students train the critical discussion of these papers. The students also get to know a number of innovative approaches for such presentations.

Content
Research in human-environment systems is characterised by a broad range of topics and methods. This is illustrated by the research papers that are discussed in this seminar. Students choose a paper from a list and present it to the seminar participants. Furthermore, they lead the discussion and train questions and answers related to such presentations. In the first three lessons, inputs to presentation techniques and innovative approaches to presentations are provided and discussed.

Lecture notes
Will be provided in the seminar.

Literature
None.

Prerequisites / notice

Resource and Environmental Economics

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.
Principles of Political Science

Objective
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

401-0649-00L Applied Statistical Regression

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Adaptability and Flexibility</td>
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<td>Customer Orientation</td>
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<td>assessed</td>
<td>assessed</td>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>assessed</td>
<td>assessed</td>
<td>Self-presentation and Social Influence</td>
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</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
</tr>
</tbody>
</table>

851-0577-00L Principles of Political Science

Abstract
This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

Objective
This course covers basic questions, concepts, theories, methods, and empirical findings of political science.
Der Kurs findet vor Ort statt und wird weder online gestreamt noch aufgezeichnet.


Leistungskontrollen
a) Erster Test (...)
b) Zweiter Test (...)
Ergeben gemittelt das Ergebnis der benoteten Semesterleistung

Kreditpunkte
4 ECTS-Punkte (Zeitaufwand insgesamt ca. 120 Arbeitsstunden)

Lecture notes

Pro Kurseinheit (Woche) sind ca. 30–40 Seiten zu lesen. Für einzelne Kurseinheiten müssen Sie etwas mehr lesen (zwei Buchkapitel, ca. 60–80 Seiten insgesamt). Es lohnt sich also, bereits von Anfang des Kurses an ein wenig «auf Vorrat» zu lesen.

Weitere Lehrmaterialien finden Sie auf: http://www.ib.etzh.ch/teaching/pwgrundlagen

Prerequisites / notice

Tutorat: Im Tutorat wird das aus der Lektüre der Buchkapitel sowie der Vorlesung mitgebrachte Wissen weiter vertieft, u.a. anhand von möglichen Testfragen. Eine regelmässige und engagierte Teilnahme am Tutorat, die gründliche Lektüre der Buchkapitel und die Teilnahme an der Vorlesung stellen sicher, dass Sie bei den Tests keine «Überraschungen» erleben werden.


Bei einer Gesamtnote (auf 2,5 gerundeter Mittelwert der beiden Tests) ≥ 4.0 gilt der Kurs als bestanden und es werden vier ECTS Punkte zugeteilt. Ausnahme: Im BA Staatswissenschaften werden die vier ECTS Punkte erst nach erfolgreichem Absolvieren der Basisprüfung zugeteilt.

Für die Studierenden des BA Staatswissenschaften ist der Inhalt dieses Kurses Prüfungsstoff für die Hälfte der Basisprüfung im Fach Politikwissenschaft, die von Prof. Bernauer durchgeführt wird (die zweite Hälfte der Basisprüfung führt Prof. Schimmelfennig durch). Das Absolvieren der beiden Tests während des Semesters ist für Studierende des BA Staatswissenschaften freiwillig, aber stark empfohlen. Über einen oder beide Tests können sich die Studierenden freiwillig bei der Kurseinheitstenzelung zugeteilt. Ausnahme: Im BA Staatswissenschaften werden die vier ECTS Punkte erst nach erfolgreichem Absolvieren der Basisprüfung zugeteilt. Für jeden der beiden Tests erhalten Sie bei einer Note von 4 oder mehr einen Bonus für die Basisprüfung im Fach Politikwissenschaft. Sie können sich also durch das Absolvieren der beiden Tests in der Basisprüfung verbessern bzw. ein Polster erwerben.

Prüfungstoff ist der gesamte Inhalt der Vorlesung und des Tutorats. Für diesen Kurs ist keine zusätzliche (separate) Prüfungsanmeldung nötig, die Anmeldung für den Kurs in mystudies deckt alles ab.

Für die beiden Tests dürfen Sie vier Seiten Notizen benutzen (zwei Blätter beidseitig beschrieben). Bitte beachten Sie, dass die Notizblätter handschriftlich beschrieben sein müssen. Elektronisch bedruckte Notizblätter werden ausnahmslos nicht zur Prüfung zugelassen.

WENN Sie gerne mehr über sozialwissenschaftliche Konzepte und Forschungsmethoden lernen möchten, sind diese beiden Bücher ausserordentlich gut:

Environmental Biology
The following courses are highly recommended as preparation for the Specialization in Environmental Biology:

227-0399-10L Physiology and Anatomy for Biomedical Engineers I (Autumn semester)
551-0448-00L Zoologie (Spring semester)
701-0360-00L Systematische Biologie: Pflanzen (Spring semester)
227-0398-10L Physiology and Anatomy for Biomedical Engineers II (Spring semester)

These courses should be successfully completed during the second year.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0301-00L</td>
<td>Applied Systems Ecology</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Gessler</td>
</tr>
</tbody>
</table>

Number of participants limited to 35.
Students will acquire skills in:

Week 1: Choice of topics and tutors

- Understanding the complexity of interactions and structures in ecosystems.
- You know how ecosystem processes, functions and services interact and feed back across multiple spatio-temporal scales (in general, plus in depth case examples).
- You understand that biodiversity and the interaction between organisms are an integral part of ecosystems. You are aware that the link between biodiversity and process/function/service is rarely fully understood. You know how to honestly deal with this lack of understanding and can nevertheless find, critically analyse and communicate solutions.
- You understand the importance of ecosystem services for society.
- You have an overview of the methods of ecosystem research and have a deeper insight into some of them, e.g. ecosystem observation, manipulation and modelling.
- You have reflected on ecology as a young discipline at the heart of significant applied questions.

The course is structured around four larger topical areas: (1) Integrated Water Management -- Green infrastructure (land management options) as an alternative to engineered solutions (e.g. large reservoirs) in flood and drought management; (2) Fire dynamics, the water cycle and biodiversity -- The surprising dynamics of species life cycles and populations in arid landscapes; (3) Rewilding, e.g. re-introducing apex predators (e.g. wolves), or large ungulates (e.g. bisons) in protected areas -- A nature conservation trend with counterintuitive effects; (4) Coupling of aquatic and terrestrial systems: carbon, nitrogen and phosphorus transfers of global importance on landscape scale.

Lecture notes

Case descriptions, commented glossary and a list of literature and further resources per case.

Prerequisites / notice

The course combines elements of a classic lecture, group discussions and problem based learning. It is helpful, but not essential to be familiar with the "seven stages" method (see e.g. course 701-0352-00L "Analysis and Assessment of Environmental Sustainability" by Christian Pohl et al.).

701-0320-00L Seminar for Bachelor Students: Environmental Biology W 3 credits 2S J. Hille Ris Lambers

Abstract

In the seminar, students explore a specific topic in environmental biology (ecology, evolution, health). They find and read scientific articles, structure their questions, talk to specialists about them, prepare a scientific presentation and lead a discussion. They are introduced to literature search and scientific presentations.

Objective

Students will acquire skills in:
- finding literature in scientific databases
- structuring a scientific topic through research questions
- giving a clear scientific presentation
- contributing constructively to a scientific discussion

Content

Week 1: Choice of topics and tutors
Week 2: Literature search
Week 4: course for presentation techniques
Weeks 1 - 5: Meetings with tutors, preparation of presentations
Weeks 5 - 14: Presentations and discussions

Lecture notes

Will be handed out during classes

701-0371-00L Ecosystem Conservation and Restoration W 3 credits 2G T. Crowther, J. Ghazoul, D. Maynard

Abstract

Conservation and restoration are interdisciplinary sciences that nonetheless are founded on fundamental ecological concepts. The course will explore theoretical underpinnings of conservation and restoration science that inform planning and implementation, and consequent outcomes. New concepts and emerging technologies will be explored, alongside case studies that inform discussions.

Objective

Through the course, students will:
- Understand the theoretical underpinnings of conservation and restoration science.
- Consider alternative conservation concepts and approaches, and the role of science and evidence in implementing these ideas in practice.
- Appraise different conservation strategies, drawing on case studies and examples from around the world.
- Explore new and emerging technologies that can be useful to guide responsible decision making in land management decisions.
- Evaluate the future direction of conservation science, in terms of new concepts (resilience, restoration, rewilding, natural capital, de-extinction) and emerging technologies (remote sensing, AI, genetics).
- Explore conservation and restoration science and practice in the context of current societal pressures, and the prospects for biodiversity conservation in coming decades.
- Understand how responsible restoration and conservation goals should integrate local practices, customs, cultures, and economic requirements.

In this course, students will:
- Learn about the historical development of thinking in conservation and restoration ecology
- Learn about the ecological theories underpinning conservation and restoration ecology
- Learn about emerging statistical and analytical tools to guide effectively responsible conservation and restoration initiatives
- Learn about the practical challenges and trade-offs in decision making that ultimately govern the success of conservation and restoration challenges around the world
- Understand, through the exploration of case studies and site visits, differing normative and management perspectives on landscape scale conservation and restoration
2021 marks the start of the UN Decade on ecosystem restoration, a global initiative to conserve and restore nature for the benefit or climate change, biodiversity and human wellbeing. As an emerging workforce enters this exponentially growing field, we hope that they will be armed with the fundamental principles that are necessary to enhance the likelihood of success.

Conservation and restoration science is a relatively young discipline, yet it has undergone substantial change in recent decades on account of changing environmental realities, new conceptual framings, and opportunities afforded by emerging technologies. As a rapidly evolving discipline, with considerable relevance and impact to environment, policy, and society, it is essential that environmental science students understand the role of science for conservation practice.

This course will explore how science and technology provides the conceptual structure and knowledge base for new approaches to conservation of biodiversity, habitats, and resources. The course will begin by examining the theoretical foundations of conservation science, and how these concepts have developed over the past century. It will examine alternative approaches to conservation ranging from traditional protected area and wildlife management systems, through to more recent concepts and approaches, including ecosystem services, natural capital, restoration, and rewilding. It will emphasize the role of new technological and analytical methods, including Earth observation, monitoring systems, AI, and genetics. Finally, the students will use a horizon scanning approach to determine the future opportunities, priorities, and constraints for conservation science and practice in our rapidly changing world.

Students will evaluate several general questions, including:
- What is conservation, and what do we want to conserve?
- What ecological theories frame conservation and restoration practice, and how can science guide conservation decisions?
- What new concepts (ecological, societal, economical) shape conservation and restoration theory and practice, and what conflicts do they engender?
- What prospects does technology offer for future conservation and restoration efforts?

Ecosystems Conservation and Restoration will provide an excellent foundation on how theoretical and applied natural and social sciences are, and can be, coupled to emerging technologies and data science to conserve and restore biodiversity and ecological functions in landscapes. For students wishing to acquire a deeper level of understanding of both science and practice in conservation and restoration, this course will serve as the prerequisite for a two-week Master-level field course (tentatively titled Conservation, Restoration, and Landscape Management) to Scotland, being developed by the Ghazoul and Crowther labs and planned for 2023. The field course will challenge students to apply the conceptual and technical understanding gained from the Ecosystem Conservation and Restoration course, specifically by working with a variety of stakeholders involved in selected forest and landscape restoration processes in Scotland.

### Literature

Current literature will be provided in due course.

### 701-1413-00L Population and Quantitative Genetics

<table>
<thead>
<tr>
<th>W</th>
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<th>2V</th>
<th>T. Städler, J. Stapley</th>
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</thead>
</table>

**Objective**

Students are able to:
- describe types and sources of genetic variation.
- describe fundamental concepts and methods of quantitative genetics.
- use basic mathematical formalism to describe major population genetic concepts.
- discuss major topics and developments in population and quantitative genetics.
- model population genetic processes using specific computer programs.

**Content**

Population Genetics:
- Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Quantitative Genetics:
- Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher’s fundamental theorem.

**Lecture notes**

Handouts

**Literature**


### 701-1413-01L Ecological Genetics

<table>
<thead>
<tr>
<th>W</th>
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<th>2V</th>
<th>A. Widmer, S. Flor, M. C. Fischer</th>
</tr>
</thead>
</table>

**Abstract**

This course focuses on fundamental concepts and methods in ecological genetics. Topics covered include genetic diversity, natural selection, adaptation, reproductive isolation, hybridization and speciation.

**Objective**

Students are familiar with fundamental concepts in ecological genetics and with current scientific methods. They can propose strategies to study evolutionary processes in natural populations by combining their knowledge from different disciplines, including population and quantitative genetics, ecology, and evolution.

**Content**

Concepts and methods for the study of genetic diversity, biodiversity, natural selection, adaptation, reproductive isolation, hybridization and speciation.

**Lecture notes**

Handouts will be provided electronically.

**Prerequisites / notice**

We recommend that you also follow the course 701-1413-00L - Population and Quantitative Genetics either in advance or in parallel.

#### Forest and Landscape

The following courses are highly recommended as preparation for the Specialization in Forest and Landscape:

- 701-0266-00L Einführung in die Dendrologie (Autumn semester)
- 701-0951-00L GIST - Einführung in die räumlichen Informationswissenschaften und -technologien (Autumn Semester)
- 551-0448-00L Zoologie (Spring semester)
- 701-0360-00L Systematische Biologie: Pflanzen (Spring semester)

These courses should be successfully completed during the second year.

### 701-0535-00L Environmental Soil Physics/Vadose Zone Hydrology

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2V+1U</th>
<th>A. Guarini, P. U. Lehmann Grunder</th>
</tr>
</thead>
</table>

**Abstract**

The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

**Objective**

Students are able to:
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils

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Content

Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid, liquid and gaseous phases; soil water content; soil texture; particle size distributions;

Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure

Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab

Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, and capillary rise); units and calculations and measurement of equilibrium soil water potential components

Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab

Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)

Week 7: Unsaturated water flow in soils - unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8: Numerical solution of Richards equation -- using Hydrus1D for simulation of unsaturated flow; choosing class project

Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow

Week 10: Root water uptake and transpiration

Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 12: Summary of lectures; solution of old exam

Week 13: Written semester-end exam

Week 14: Short presentations of Hydrus class projects; discussion of written exam

Literature

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

701-0553-00L Landcape Ecology W 3 credits 2G F. Kienast, L. Pellissier

Abstract
The course is an introduction to Landscape Ecology and Landscape Modelling and provides various practical applications of Landscape Ecology in nature and landscape management.

Objective
The students are able
- to explain and apply the concepts and methods of landscape analysis using examples,
- to explain causes and effects of changes in landscape using examples and simulations,
- to describe practical applications of Landscape Ecology in the management of nature and landscape.

Content
Contents of the lecture:
- important terms and concepts of Landscape Ecology,
- analysis of landscape pattern (metrics),
- landscape modelling,
- perception of landscapes,
- landscape inventories used for nature and landscape protection.

Lecture notes
The course is offered via a MOOC (Edx)

Prerequisites / notice
This lecture is coordinated with a MOOC.

It is advantageous but not required to have some GIS knowledge for this lecture and the practical 'Praktikum Wald und Landschaft' (spring semester) which is loosely linked with this lecture.

701-0559-00L Seminar for Bachelor Students: Forest and Landscape W 3 credits 2S M. Lévesque, T. Ohmura

Abstract
Interdisciplinary seminar on forest and landscape issues with particular emphasis on the key processes shaping the development of forest ecosystems and landscapes.

Objective
- To critically analyze and discuss original scientific articles for selected processes and methods in relation to forest and landscape.
- Scientific exchange with subject-specific experts.
- Learn standard rhetoric and moderation methods through training in the seminar.
- Effective feedback regarding the independent development of presentation and moderation competencies.

Content
Seminars will deal with the following topics: 1) Biological, ecological and physical processes, and technical aspects in forest ecosystems with effects on the community, ecosystem and landscape; 2) Social and political processes and institutions with relation to land use; 3) Products and services of forest ecosystems and landscapes and 4) Forest management systems. The contributions will be grouped by topics. Furthermore, the seminar teaches rhetoric and moderation methods, which will serve to deepen the above topics through presentations and discussions.

Lecture notes
There will be a script for the rhetoric and moderation methods.

Literature
Literature references will be provided by the lecturers.

Prerequisites / notice
The credits are assigned if the following requirements are met
a) Independent literature research on the topic and exchange with experts for preparing for the presentation
b) Presentation with questions and answers (15-20 min)
c) Moderation of the scientific discussion (20-35 min)
d) Actively contributing to the feedback of students' presentations, moderation and discussions.

The presentations can be made in German or English.

We expect a regular and active participation.
701-0561-00L  Forest Ecology  W  3 credits  2V  H. Bugmann

Abstract
This course conveys the basics of forest ecology with an emphasis on trees as those organisms that dominate the physiognomy and the dynamics of forest ecosystems. Based on this course, students have a good grasp of the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with a focus on central Europe.

Objective
Students are able to:
- summarize the fundamentals of forest ecology at the autecological, demecological and synecological level
- explain how trees dominate the physiognomy and dynamics of forest ecosystems
- describe the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with an emphasis on central Europe and Alpine region.

Overall, the competences of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught and examined in this course.

Content
Introduction and overview of the forests of the world
Forest ecosystem ecology; Production ecology of forests
Auteology: light, temperature, wind, water, and nutrients
Demecology: regeneration ecology, forest growth, mortality
Synecology: fundamentals of trophic interactions (forest-ungulate interactions), succession

Lecture notes
Handouts (mixture of overhead slides and full text chapters) are sold at cost
Relevant chapters from textbooks will be indicated.

Literature

701-0565-00L  Principles of Natural Hazard Management  W  3 credits  4G  V. Griess, A. Mathys

Abstract
This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.

Objective
By the end of the course, students will be able to:
- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.
- develop, formulate and present solutions to these challenges to a critical audience.

Content
- the various groups of tree pathogens (fungi, oomycetes, bacteria, viruses) as well as abiotic causes of tree diseases.
- the most important concepts such as forest health, disposition, resistance, interactions, vectors, epidemiology, outbreaks, invasive species and climatic factors.
- methods for monitoring and sustainable prevention and limitation of damage from insects and pathogens.

Literature
will be distributed and available on Moodle

701-0567-00L  Forest Health: Entomology and Pathology  W  3 credits  2V+1P  E. Brockerhoff, V. Queloz

Abstract
Insects and microorganisms are important components of the biodiversity and ecology of forests. This course covers the diversity, biology and ecology of insects and pathogens, both native and non-native species and especially those that are tree pests or cause diseases. The course also covers entomological and pathological methods, forest protection and other relevant topics.

Objective
Basic knowledge of:
- biology, ecology and biodiversity of insects and the main insect orders with examples of beneficial and pest species of trees and forests of central Europe.
- the various groups of tree pathogens (fungi, oomycetes, bacteria, viruses) as well as abiotic causes of tree diseases.
- the most important concepts such as forest health, disposition, resistance, interactions, vectors, epidemiology, outbreaks, invasive species and climatic factors.
- methods for monitoring and sustainable prevention and limitation of damage from insects and pathogens.

Content
- Einführung Lernziele, Grundbegriffe, Waldgesundheit
- Einführung Insekten: Biologie, Morphologie, Physiologie und Ökologie
- Einführung Pilze: Taxonomie, Strukturen des Thallus, Fruchtkörper, Sexualität der Asko- und Basidiomyzeten, Pilzkunde, Fäulearten
- Borkenkäfer und andere Rinden- und Holzbewohner, Schmetterlinge und andere Entlauber
- Blattläuse und andere Pflanzensauger, Gallbildner, Samen- und Zapfeninsekten
- Insekten und Pathogene – Vektoren und Komplexkrankheiten
- Wurzel- und Stammfäulen
- Abwehr im Baum gegen Pathogene - CODIT
- Rostkrankheiten
- Nützlinge, natürlich Feinde, Artenvielfalt, Biodiversität, Naturschutz
- Entomologische Methoden (Feld, Labor, Analysen, Schadensbegrenzung)
- Welkeerreger und Bläuepilze, Rindennekrosen
- Nadel- und Blattkrankheiten
— Bachelor's Thesis

Students can choose between one Bachelor thesis of 10 KP or two Bachelor theses of 5 KP each.

In principle, all professors and lecturers involved in the teaching of the Environmental Sciences degree programme are entitled to supervise a Bachelor's thesis (BA).

BA in the area of social sciences and humanities can only be supervised by lecturers who teach in this area. The same applies to BA in the field of natural sciences and technology.

If the thesis is supervised by a person who does not teach in the Environmental Sciences degree programme or who does not have ETH lecturer status, then the student has to fill in the "Form for supervisors of a Bachelor thesis who do not teach in the Environmental Sciences degree programme" https://ethz.ch/content/dam/ethz/special-interest/usys/department/documents/studium/umweltwissenschaften/bachelor/bsc-envsci-supervisors-not-listed-mystudies.pdf

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<tbody>
<tr>
<td>701-0010-02L</td>
<td>Short Bachelor's Thesis in Social Sciences and Humanities</td>
<td>W</td>
<td>5 credits</td>
<td>1D</td>
<td>Lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>By developing the bachelor's thesis, students learn to (a) analyse a problem using scientific methods and concepts, (b) write a report according to scientific standards and (c) correctly cite scientific literature. Depending on the chosen orientation of the thesis, the students learn these skills through an empirical analysis, a literature review, via design tasks or through an applied project.</td>
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<tr>
<td>Content</td>
<td>A bachelor's thesis in the domain &quot;Social sciences and humanities&quot; usually deals with an issue at the interface of those sciences, the environment and sustainability. Methods of data collection, analysis and interpretation stemming from the social sciences are applied. A short bachelor's thesis should consist of a text, with graphs and figures, of 15-20 pages.</td>
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<tr>
<td>Content</td>
<td>A bachelor's thesis in &quot;Natural sciences&quot; deals with a topic at the interface of natural sciences, the environment and sustainability. The methods of data collection, analysis and interpretation appropriate to the natural sciences are used. An thesis in &quot;Engineering&quot; deals with the environmental effects of use and application. The thesis may take the form of an analysis or review of a current technology, or the design of a future technological application. In an inter- or transdisciplinary thesis, knowledge from various fields and disciplines would be merged on the basis of an overarching question, or developed via the input of key societal actors. A short bachelor's thesis should consist of a text, with graphs and figures, of 15-20 pages.</td>
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<td>Bachelor's Thesis</td>
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<td>2D</td>
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<td>By developing the bachelor's thesis, students learn to (a) analyse a problem using scientific methods and concepts, (b) write a report according to scientific standards and (c) correctly cite scientific literature. Depending on the chosen orientation of the thesis, the students learn these skills through an empirical analysis, a literature review, via design tasks or through an applied project.</td>
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<tr>
<td>Content</td>
<td>The BA is written either under the &quot;Social sciences and humanities&quot; or the &quot;Natural sciences and technology&quot; modules. The thesis may also be inter- and transdisciplinary. A bachelor's thesis in the domain &quot;Social sciences and humanities&quot; usually deals with an issue at the interface of those sciences, the environment and sustainability. Methods of data collection, analysis and interpretation stemming from the social sciences are applied. A bachelor's thesis in &quot;Natural sciences&quot; deals with a topic at the interface of natural sciences, the environment and sustainability. The methods of data collection, analysis and interpretation appropriate to the natural sciences are used. A thesis in &quot;Technology&quot; deals with the environmental effects of use and application. The thesis may take the form of an analysis or review of a current technology, or the design of a future technological application. In an inter- or transdisciplinary thesis, knowledge from various fields and disciplines would be merged on the basis of an overarching question, or developed via the input of key societal actors. A bachelor's thesis should consist of a text, with graphs and figures, of 30-40 pages.</td>
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<tr>
<td>701-0010-01L</td>
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Environmental Sciences Bachelor - Key for Type

<table>
<thead>
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<th>Key for Hours</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>V lecture</td>
<td></td>
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<tr>
<td>G lecture with exercise, Z</td>
<td></td>
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<tr>
<td>U exercise</td>
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<tr>
<td>S seminar</td>
<td></td>
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<tr>
<td>K colloquium</td>
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</table>

Key for Hours

Special students and auditors need special permission from the lecturers.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2166 of 2345
### Environmental Sciences Master

**▶ Major in Atmosphere and Climate**

#### Prerequisites

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>701-0471-01L</td>
<td>Atmospheric Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Ammann, T. Peter</td>
</tr>
<tr>
<td>701-0473-00L</td>
<td>Weather Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. A. Sprenger, F. Scholder-Aemisegger</td>
</tr>
<tr>
<td>701-0475-00L</td>
<td>Atmospheric Physics</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>F. Mahrt</td>
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</table>

**Abstract**

- This self-study course provides an introduction to atmospheric chemistry at bachelor level. It introduces the fundamentals of gas phase reactions, the concept of solubility and reactions in aerosols and in clouds. It explains the chemical and physical processes responsible for global (e.g. stratospheric ozone depletion) as well as regional environmental problems (e.g. urban air pollution).

**Objective**

- The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere.

**Content**

- Origin and properties of the atmosphere: structure, large scale dynamics, UV radiation
- Thermodynamics and kinetics of gas phase reactions: enthalpy and free energy of reactions, rate laws, mechanisms of biomolecular and termolecular reactions.
- Tropospheric photochemistry: Photolysis reactions, photochemical O3 formation, role and budget of HOx, dry and wet deposition
- Aerosols and clouds: chemical properties, primary and secondary aerosol sources, phase transfer kinetics, solubility and hygroscopicity, N2O5 chemistry, SO2 oxidation, secondary organic aerosols
- Air quality: role of planetary boundary layer, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Stratospheric chemistry: Chapman cycle, Brewer-Dobson circulation, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
- Global aspects: global budgets of ozone, methane, CO and NOx, air quality - climate interactions

**Lecture notes / notice**

- Lecture materials (slides and annotations) of the most recent corresponding bachelor course are provided.

**Prerequisites**

- Basic courses in chemistry and physics are expected

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2167 of 2345
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Objective
Training scientific writing skills.

Abstract
Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not necessary, a Python introduction is provided). Example programs and graphics tools are supplied.

Lecture notes

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<tbody>
<tr>
<td>701-1211-01L</td>
<td>Master's Seminar: Atmosphere and Climate 1</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>H. Joos, R. Knutti, A. Merrifield Köhnz, M. A. Wüst</td>
</tr>
</tbody>
</table>

Objective
The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

Abstract
The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

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<td>H. Joos, R. Knutti, A. Merrifield Köhnz, M. A. Wüst</td>
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Abstract
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Objective
Training scientific writing skills.
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other’s work.

Prerequisites / notice
Attendance is mandatory.

701-1211-02L Master's Seminar: Atmosphere and Climate 2

Target groups only: Master Environmental Science Master Atmospheric and Climate Science

Abstract
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

Objective
Apply scientific project management techniques to your master project, practice the presentation of scientific results and how to chair other students presentations and lead the discussion.

Content
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

Prerequisites / notice
Attendance is mandatory.

Weather Systems and Atmospheric Dynamics

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<tbody>
<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Wernli, L. Papritz</td>
</tr>
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</table>

Abstract
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Objective
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

Content
Dynamical Meteorology is concerned with the dynamical processes of the earth’s atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes
Dynamics of large-scale atmospheric flow

Literature
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Climate Processes and Feedbacks

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<th>Number</th>
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<tbody>
<tr>
<td>701-1235-00L</td>
<td>Cloud Microphysics</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>Z. A. Kanji, N. Shardt, Y. Wang</td>
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</table>

Number of participants limited to 20. The lecture takes place if a minimum of 7 students register for it.

Priority is given to PhD students majoring in Atmospheric and Climate Sciences, and remaining open spaces will be offered to the following groups: - PhD student Environmental sciences - MSc in Atmospheric and climate science - MSc in Environmental sciences

All participants will be on the waiting list at first. Enrollment is possible until 14.09.2022. The waiting list is active until 30.09.2022. All students will be informed on
Powerpoint slides will be made available.

Title

Land-Climate Dynamics

Number of participants limited to 36.

Abstract
The target groups are the following:
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.

Objective
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

Lecture notes
Powerpoint slides will be made available.

Prerequisites / notice
Prerequisites: Introductory lectures in atmospheric and climate science


Objective
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Documents are provided in the contact hours.

Literature

Prerequisites / notice
Prerequisites: Basics in physical chemistry are required and an overview equivalent to the bachelor course in atmospheric chemistry (lecture 701-0471-01) is expected.

Atmospheric Composition and Cycles

Number Title Type ECTS Hours Lecturers
701-1233-00L Stratospheric Chemistry W 4 credits 2V+1U T. Peter, G. Chiodo

Abstract
The lecture gives an overview on the manifold reactions which occur in the gas phase, in stratospheric aerosol droplets and in polar cloud particles. The focus is on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.

Objective
The students will understand the most important aspects of stratospheric dynamics and the greenhouse gas effect in troposphere and stratosphere.

Furthermore, they will practise to explain fundamental concepts in stratospheric chemistry by means of scientific paper presentations.

Content
Short presentation of thermodynamical and kinetic basics of chemical reactions: bi- and termolecular reactions, photo-dissociation. Introduction to the chemical family concept: active species, their source gases and reservoir gases. Detailed treatment of the pure oxygen family (odd oxygen) according to the Chapman chemistry. Radical reactions of the oxygen species with nitric oxide, active halogens (chlorine and bromine) and odd hydrogen. Ozone depletion cycles. Methane depletion and ozone production in the lower stratosphere (photo-smog reactions). Heterogeneous chemistry on the background aerosol and its significance for heavy air traffic. Chemistry and dynamics of the ozone hole: Formation of polar stratospheric clouds and chlorine activation.

Lecture notes
Documents are provided in the contact hours.

Literature
- MSc in Environmental sciences
- MSc in Atmospheric and climate science
- PhD student Environmental sciences

The target groups are the following:
- Introductory lectures in atmospheric and climate science


Objective
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Powerpoint slides will be made available.

Prerequisites / notice
Prerequisites: Introductory lectures in atmospheric and climate science


701-1251-00L Land-Climate Dynamics

Number of participants limited to 36.

The target groups are the following:
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.

Abstract
The lecture gives an overview on the manifold reactions which occur in the gas phase, in stratospheric aerosol droplets and in polar cloud particles. The focus is on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.

Objective
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Powerpoint slides will be made available.

Prerequisites / notice
Prerequisites: Introductory lectures in atmospheric and climate science

The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?
2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?
3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?
4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?
5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.
### Hydorlogy and Water Cycle

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<td>701-1251-00L</td>
<td>Land-Climate Dynamics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. I. Seneviratne, R. Padrón Flasher, P. Sieber</td>
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<td></td>
<td>Number of participants limited to 36.</td>
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<tr>
<td>Abstract</td>
<td>The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises. Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.</td>
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<tr>
<td>Objective</td>
<td>The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises. Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.</td>
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<tr>
<td>Lecture notes</td>
<td>The students can understand the role of land processes and associated feedbacks in the climate system.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Powerpoint slides will be made available</td>
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<tr>
<td>Prerequisites</td>
<td>Prerequisites: Introductory lectures in atmospheric and climate science</td>
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### Analysis of Climate and Weather Data

<table>
<thead>
<tr>
<th>Number</th>
<th>Analysis of Climate and Weather Data</th>
<th>W</th>
<th>3</th>
<th>2G</th>
<th>C. Frei</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purposes of methods, can apply them independently and know how to interpret results professionally.</td>
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<tr>
<td>Objective</td>
<td>Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.</td>
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<tr>
<td>Content</td>
<td>The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.</td>
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<tr>
<td>Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.</td>
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<tr>
<td>Lecture notes</td>
<td>The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.</td>
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<tr>
<td>Prerequisites</td>
<td>Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.</td>
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### Watershed Modelling

<table>
<thead>
<tr>
<th>Number</th>
<th>Watershed Modelling</th>
<th>W</th>
<th>6</th>
<th>4G</th>
<th>P. Molnar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>A practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of results. The course combines theory (lectures) with a series of practical tasks (exercises).</td>
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<tr>
<td>Objective</td>
<td>The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical exercises to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.</td>
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<tr>
<td>Content</td>
<td>The first part (A) of the course is on watershed properties examined from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focused on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.</td>
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<tr>
<td>Lecture notes</td>
<td>There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.</td>
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<tr>
<td>Literature</td>
<td>Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).</td>
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</table>
### Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Assessed</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td></td>
<td>Self-direction and Self-management</td>
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<tr>
<td></td>
<td>Problem-solving</td>
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</tbody>
</table>

### Abstract
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

### Objective
Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

### Content
- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

### Literature

### Prequisites / notice
Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science.

### Electives
#### Weather Systems and Atmospheric Dynamics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1281-00L</td>
<td>Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS)</td>
<td>W</td>
<td>3</td>
<td>6A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Students are allowed to enroll in both courses 701-1280-00L & 701-1281-00L Self-learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.

Abstract
This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:
- atmospheric chemistry
- atmospheric dynamics
- atmospheric physics
- climate modeling
- climate physics
- land-climate dynamics
- atmospheric circulation
- paleoclimate
- ocean biogeochemical dynamics

Objective
The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

Content
The course has the following elements:
- Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
- Week 2: General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University: https://www.coursera.org/learn/sciwri?action=enroll
- Weeks 6 and 9: Meetings with supervisor to clarify scientific questions
- Week 12: Hand-in of written summary (4 pages maximum)
- Week 14: Supervisor provides written feedback to the summary document
- Week 16: Oral exam about the scientific topic

Literature
Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.
Prerequisites depend on the chosen field and include successful completion of the listed lecture courses:

- atmospheric dynamics: "Dynamics of large-scale atmospheric flow" (701-1221-00L)
- atmospheric chemistry: "Stratospheric Chemistry" (701-1233-00L) or "Tropospheric Chemistry" (701-1234-00L) or "Aerosols I" (402-0572-00L)
- atmospheric physics: "Atmospheric Physics" (701-0475-00L)
- climate physics: "Klimasysteme" (701-0412-00L) or equivalent
- land-climate dynamics: "Land-climate dynamics" (701-1251-00L)
- climate modeling: "Numerical modeling of weather and climate" (701-1216-00L) (parallel attendance possible)
- atmospheric circulation: "Dynamics of large-scale atmospheric flow" (701-1221-00L)
- paleoclimate: "Climate History and Paleoclimatology" (651-4057-00L)
- ocean biogeochemical dynamics: "Global Biogeochemical Cycles and Climate" (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

### Climate Processes and Feedbacks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Wernli, L. Papritz</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (qualitative and quantitative) form an essential part of the course.</td>
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<tr>
<td>Objective</td>
<td>Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.</td>
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<tr>
<td>Content</td>
<td>Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.</td>
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<tr>
<td>Lecture notes</td>
<td>Dynamics of large-scale atmospheric flow</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Physics I, II, Environmental Fluid Dynamics</td>
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<thead>
<tr>
<th>Number</th>
<th>European Climate Change</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1257-00L</td>
<td>European Climate Change</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>C. Schär, J. Rajczak, S. C. Scherrer</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics: observational datasets, observation and detection of climate change; underlying physical processes and feedbacks; numerical and statistical approaches; currently available projections.</td>
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<tr>
<td>Objective</td>
<td>At the end of this course, participants should: understand the key physical processes shaping climate change in Europe; know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches; be familiar with relevant observational and modeling data sets; be able to tackle simple climate change questions using available data sets.</td>
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<tr>
<td>Content</td>
<td>Contents: global context; observational datasets, analysis of climate trends and climate variability in Europe; global and regional climate modeling; statistical downscaling; key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects; projections of European and Alpine climate change</td>
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<tr>
<td>Lecture notes</td>
<td>Slides and lecture notes will be made available at <a href="http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html">http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html</a></td>
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<tr>
<td>Prerequisites / notice</td>
<td>Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.</td>
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<tr>
<th>Number</th>
<th>Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS)</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1281-00L</td>
<td>Please contact one of the professors listed under prerequisites/notice if you plan to take this course.</td>
<td>W</td>
<td>3</td>
<td>6A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students are allowed to enroll in both courses 701-1280-00L &amp; 701-1281-00L Self-learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.</td>
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<tr>
<td></td>
<td>This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields: atmospheric chemistry; atmospheric dynamics; atmospheric physics; climate modeling; climate physics; land-climate dynamics; atmospheric circulation; paleoclimate; ocean biogeochemical dynamics</td>
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</table>

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2174 of 2345
The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

The course has the following elements:

**Objective**

Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)

Week 2: General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University:

https://www.coursera.org/learn/sciwrite?action=enroll

Weeks 6 and 9: Meetings with supervisor to clarify scientific questions

Week 12: Hand-in of written summary (4 pages maximum)

Week 14: Supervisor provides written feedback to the summary document

Week 16: Oral exam about the scientific topic

**Content**

Prerequisites depend on the chosen field and include successful completion of the listed lecture courses:

- atmospheric dynamics: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- atmospheric chemistry: “Stratospheric Chemistry” (701-1233-00L) or “Tropospheric Chemistry” (701-1234-00L) or “Aerosols I” (402-3572-00L)
- atmospheric physics: “Atmospheric Physics” (701-0475-00L)
- climate physics: “Klimasysteme” (701-0412-00L) or equivalent
- land-climate dynamics: “Land-climate dynamics” (701-1251-00L)
- climate modeling: “Numerical modeling of weather and climate” (701-1216-00L) (parallel attendance possible)
- atmospheric circulation: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- paleoclimate: “Climate History and Paleoclimate” (651-4057-00L)
- ocean biogeochemical dynamics: “Global Biogeochemical Cycles and Climate” (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

**Literature**

Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.

**Prerequisites / notice**

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

**ECTS**

651-4057-00L Climate History and Paleoclimateology W 4 credits 2G H. Stoll, I. Hernández Almeida, H. Zhang

**Number of participants limited to 20.** The lecture takes place if a minimum of 7 students register for it.

Priority is given to PhD students majoring in Atmospheric and Climate Sciences, and remaining open spaces will be offered to the following groups:

- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

**Objective**

Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

**Abstract**

The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

**Content**

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### Atmospheric Composition and Cycles

**Number**

<table>
<thead>
<tr>
<th>701-1235-00L</th>
<th>Cloud Microphysics</th>
</tr>
</thead>
</table>

**Type**

W 4 credits 2V+1U

**Lecturers**

Z. A. Kanji, N. Shardi, Y. Wang

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 2175 of 2345
All participants will be on the waiting list at first. Enrollment is possible until 14.09.2022. The waiting list is active until 30.09.2022. All students will be informed on 15./16.09.2022, if they can participate in the lecture.

Abstract
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

Objective
The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.

Content

Lecture notes
This course will be designed as a reading course in 1-2 small groups of 10 students maximum. It will be based on the textbook below. The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth.

Literature
Lamb and Verlinde: PHYSICS AND CHEMISTRY OF CLOUDS, Cambridge University Press, 2011

Prerequisites / notice
Target group: Doctoral and Master students in Atmosphere and Climate

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
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<td>assessed</td>
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</table>

701-1281-00L Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS) 3 credits 6A

W
Supervisors

Please contact one of the professors listed under prerequisites/notice if you plan to take this course.

Students are allowed to enroll in both courses 701-1280-00L & 701-1281-00L Self-learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.

Abstract
This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:
- atmospheric chemistry
- atmospheric dynamics
- atmospheric physics
- climate modeling
- climate physics
- land-climate dynamics
- atmospheric circulation
- paleoclimate
- ocean biogeochemical dynamics

Objective
The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

Content
The course has the following elements:
- Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
- Week 2: General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University: https://www.coursera.org/learn/sciwrite?action=enroll
- Weeks 6 and 9: Meetings with supervisor to clarify scientific questions
- Week 12: Hand-in of written summary (4 pages maximum)
- Week 14: Supervisor provides written feedback to the summary document
- Week 16: Oral exam about the scientific topic

Literature
Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.

Prerequisites / notice
Prerequisites depend on the chosen field and include successful completion of the listed lecture courses:
- atmospheric dynamics: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- atmospheric chemistry: “Stratospheric Chemistry” (701-1233-00L) or “Tropospheric Chemistry” (701-1234-00L) or “Aerosols I” (402-0572-00L)
- atmospheric physics: “Atmospheric Physics” (701-0475-00L)
- climate physics: “Klimasysteme” (701-0412-00L) or equivalent
- land-climate dynamics: “Land-climate dynamics” (701-1251-00L)
- climate modeling: “Numerical modeling of weather and climate” (701-1216-00L) (parallel attendance possible)
- atmospheric circulation: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- paleoclimate: “Climate History and Paleoclimate” (651-4057-00L)
- ocean biogeochemical dynamics: “Global Biogeochemical Cycles and Climate” (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.
- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

102-0635-01L Air Pollution Control W 6 credits 4G J. Wang, B. Buchmann
The lecture provides in the first part an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and their impact on air quality. The second part covers different strategies and techniques for emission reduction. The basic knowledge is deepened by the discussion of specific air pollution problems of today’s society.

The students gain general knowledge of the technical processes resulting in air pollution and study the methods used for air pollution control. The students can identify major air pollution sources and understand the methods for measuring pollutants, collecting and analyzing data. The students can suggest and evaluate possible control methods and equipment, design control systems and estimate their efficiency and efforts.

The students know the different strategies of air pollution control and are familiar with their scientific fundamentals. They are able to incorporate goals concerning air quality into their engineering work.

**Abstract**

- Fluxes of pollutants and their environmental impact:
  - physical and chemical processes leading to emission of pollutants
  - mass and energy of processes
  - Emission measurement techniques and concepts
  - quantification of emissions from individual and aggregated sources
  - extent and development of the emissions (Switzerland and global)
  - propagation and transport of pollutants (transmission)
  - meteorological parameters influencing air pollution dispersion
  - deterministic and stochastic models, describing air pollution dispersion
  - dispersion models (Gaussian model, box model, receptor model)
  - measurement concepts for ambient air (immission level)
  - extent and development of ambient air mixing ratios
  - goal and instrument of air pollution control

**Objective**

- Part 1 Emission, Immission, Transmission
  - Concepts for non-ideal boundary layer conditions
  - Spectral characteristics
  - Scaling and similarity theory
  - Closure problem and closure assumptions
  - Conservation equations in a turbulent flow
  - Statistical treatment of turbulence, turbulent transport

**Content**

- Part 2 Air Pollution Control Technologies
  - goal and instrument of air pollution control
  - extent and development of ambient air mixing ratios
  - measurement concepts for ambient air (immission level)
  - goal and instrument of air pollution control

**Lecture notes**

- Brigitte Buchmann, Air pollution control, Part I
- Jing Wang, Air pollution control, Part II

**Literature**

- List of literature included in script

**Prerequisites / notice**

- College lectures on basic physics, chemistry and mathematics.

**Language of instruction:** In German or in English.

**Taught competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Project Management
- Problem-solving

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Group and Team Management
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**651-4053-05L Boundary Layer Meteorology**

**Abstract**

The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth’s surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

**Objective**

- Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts.
- Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

**Content**

- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions
**Climate History and Palaeoclimatology**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1281-00L</td>
<td>Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS)</td>
<td>W</td>
<td>3 credits</td>
<td>6A</td>
<td>Supervisors</td>
</tr>
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*Please contact one of the professors listed under prerequisites/notice if you plan to take this course.

**Prerequisites / notice**

Students are allowed to enroll in both courses 701-1280-00L & 701-1281-00L Self-learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.

**Abstract**

This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:

- atmospheric chemistry
- atmospheric dynamics
- atmospheric physics
- climate modeling
- climate physics
- land-climate dynamics
- atmospheric circulation
- paleoclimate
- ocean biogeochemical dynamics

**Objective**

The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

**Content**

The course has the following elements:

- Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
- Week 2: General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University: https://www.coursera.org/learn/sciwrite?action=enroll
- Week 6 and 9: Meetings with supervisor to clarify scientific questions
- Week 12: Hand-in of written summary (4 pages maximum)
- Week 14: Supervisor provides written feedback to the summary document
- Week 16: Oral exam about the scientific topic

**Literature**

Prerequisites depend on the chosen field and include successful completion of the listed lecture courses:

- atmospheric dynamics: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- atmospheric chemistry: “Stratospheric Chemistry” (701-1233-00L) or “Tropospheric Chemistry” (701-1234-00L) or “Aerosols I” (402-0972-00L),
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- paleoclimate: “Climate History and Paleoclimate” (651-4057-00L)
- ocean biogeochemical dynamics: “Global Biogeochemical Cycles and Climate” (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

**Sedimentology I: Physical Processes and Sedimentary Systems**

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>651-4041-00L</td>
<td>Sedimentology I: Physical Processes and Sedimentary Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti</td>
</tr>
</tbody>
</table>

**Abstract**

Sediments preserve a record of past landscapes. This course focuses on understanding the processes that modify sedimentary landscapes with time and how we can read these changes in the sedimentary record.

**Objective**

The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.

**Content**

Details on the program will be handed out during the first lecture.

**Literature**

The sedimentary record of sea-level change


**Prerequisites / notice**

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

**Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems**

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
</tr>
</tbody>
</table>

Prerequisite: Successful completion of the MSc-course “Sedimentology I” (651-4041-00L).
Abstract
The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

Objective
- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

Content
- carbonates, chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg: CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine sediments through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

Lecture notes
no script. scientific articles will be distributed during the course

Literature
We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

651-4901-00L Quaternary Dating Methods W 3 credits 2G I. Hajdas, M. Christl, S. Ivy Ochs

Abstract
Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.

Objective
Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

At the end of the course students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. be able to calculate an age based on data of the six methods studied.
3. choose which dating method (or combination of methods) is suitable for a certain field problem.
4. critically read and evaluate the application of dating methods in scientific publications.

Content
1. Introduction: Time scales for the Quaternary, Isotopes and decay
2. Radiocarbon dating: principles and applications
3. Cosmogenic nuclides: 3He,10Be, 14C, 21Ne, 26Cl, 36Cl
4. U-series disequilibrium dating
5. Luminescence dating
6. Introduction to incremental: varve counting, dendrochronology and ice cores chronologies
7. Cs-137 and Pb-210 (soil, sediments, ice core)
8. Summary and comparison of results from several dating methods at specific sites

Prerequisites / notice
Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.

Optional (individual): 1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggerebgr

Required: attending the lecture, visiting laboratories, handing back solutions for problem sets (Exercises)

Hydrology and Water Cycle

Number Title Type ECTS Hours Lecturers
701-0535-00L Environmental Soil Physics/Vadose Zone Hydrology W 3 credits 2V+1U A. Carminati, P. U. Lehmann Grunder

Abstract
The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

Objective
Students are able to
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils

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Content

Week 1: Introduction, soil and vadose zone, units and dimensions, definitions and basic mass-volume relationships between the solid, liquid and gaseous phases; soil water content; soil texture; particle size distributions;

Week 2: Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation, surface area, soil structure

Week 3: Capillarity – capillary rise, surface tension, Young-Laplace equation; Washburn equation; numerical lab

Week 4: Soil Water Potential - the energy state of soil water; total water potential and its components; properties of water (molecular, surface tension, and capillary rise); units and calculations and measurement of equilibrium soil water potential components

Week 5: Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; demo lab

Week 6: Saturated water flow in soils - laminar flow in tubes (Poiseuille’s Law); Darcy’s Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman)

Week 7: Unsaturated water flow in soils - unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8: Numerical solution of Richards equation – using Hydrus1D for simulation of unsaturated flow; choosing class project

Week 9: Energy balance and land atmosphere interactions - radiation and energy balance; evapotranspiration, definitions and estimation; evaporation stages and characteristic length; soil thermal properties; steady state heat flow; non-steady heat flow

Week 10: Root water uptake and transpiration

Week 11: Solute and gas transport in soils; transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 12: Summary of lectures; solution of old exam

Week 13: Written semester-end exam

Week 14: Short presentations of Hydrus class projects; discussion of written exam

Literature

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

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Weeks 6 and 9: Meetings with supervisor to clarify scientific questions
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Week 14: Supervisor provides written feedback to the summary document
Week 16: Oral exam about the scientific topic

Literature

Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, predicting of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems. Students are able to formulate simple, practical groundwater flow and solute transport problems. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, formulating, and solving groundwater flow and solute transport problems. Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions.

Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

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Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems. Students are able to formulate simple, practical groundwater flow and solute transport problems. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Senn)
The course will provide advanced physical understanding on the fundamentals of passive and active remote sensing, measuring sensors and retrieval methods. A series of diverse remote sensing applications will be presented, including measurements/retrievals of various atmospheric composition parameters (ozone, aerosols, clouds, others) from surface based and satellite based instruments.

Abstract
This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Objective
Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content
The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

Key challenges in international river systems

20.Sep Global water challenges
27.Sep Nuts and bolts of hydrological modeling and what such models can tell us
04.Oct Nuts and bolts of hydrological modeling and what such models can tell us
11.Oct Water pollution and its mitigation
18.Oct Key challenges in international river systems
25.Oct Key challenges in international river systems
01.Nov Case study 1: Yarmuk
08.Nov Case study 2: Mekong
15.Nov Case study 3: Colorado
22.Nov Case study 4: Nile
29.Nov Case study 5: Central Asia
06.Dec Wrap up: what we can learn from these case studies
13.Dec Exam
20.Dec No class

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Additional Elective Courses

The course will provide advanced physical understanding on the fundamentals of passive and active remote sensing, measuring sensors and retrieval methods. A series of diverse remote sensing applications will be presented, including measurements/retrievals of various atmospheric composition parameters (ozone, aerosols, clouds, others) from surface based and satellite based instruments.

Abstract
The students will learn how various components of the atmosphere are retrieved from radiation measurements, both from surface and satellite-based measurements.

Objective
The course will provide advanced physical understanding on the fundamentals of passive and active remote sensing, measuring sensors and retrieval methods. A series of diverse remote sensing applications will be presented, including measurements/retrievals of various atmospheric composition parameters (ozone, aerosols, clouds, others) from surface based and satellite based instruments.

Content
The proposed lesson is divided in three sections including exercises:
- Fundamentals of remote sensing
- Sensors (surface based and satellites) and retrieval methods
- Applications

The first aim of the lecture is to provide an in-depth understanding of the physical aspects and basic laws on the fundamentals of remote sensing to the students. The lectures will provide a basic to intermediate understanding of radiative transfer of electromagnetic radiation through the atmosphere, covering the spectrum from UV to thermal. Examples of atmospheric components that will be addressed are: ozone, aerosols, greenhouse gases, clouds, water vapor.

In addition, measuring sensors used from the surface or from satellites and the relevant retrieval methods based on passive and active remote sensing of atmospheric composition will be presented (e.g. Spectroradiometers, filter radiometers, Lidars and others).

Finally, we aim to demonstrate a series of diverse remote sensing applications, including atmospheric composition measurements and retrievals from surface- and satellite-based instruments, including calibration and validation aspects.

The exercises will be embedded in the overall course lectures to provide hands-on experience with the measurements and retrieval methods using datasets available from specific instruments (e.g. satellite sensors) and networks (e.g. EUBREWNET, AERONET, GAWPFR).
Lecture notes
Lecture slides will be provided.

Prerequisites / notice
none

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

701-1271-00L Statistical Learning for Atmospheric and Climate Science
- Number of participants limited to 30.
- Enrollment starts on 19.09.2022
- Priority is given to the target groups: Master Environmental Science and Master Atmospheric and Climate Science until 26.09.2022.
- Waiting list will be deleted on 03.10.2022.

Abstract
The course will consist of overview lectures, hands-on practical exercises on (1) the basics of statistical learning and (2) with a focus on applications for atmospheric and climate science. Lectures will cover theoretical basics of statistical learning (advanced regression, nonlinear methods) and an overview of applications of statistical learning in the atmospheric and climate sciences.

Objective
- Understanding elements and principals of statistical learning
- Ability to select the appropriate statistical learning tools to tackle atmospheric and climate research problems
- Ability to apply methods of statistical learning to atmospheric and climate research

Content
- Data in atmospheric and climate research (data types, observations, models)
- Exploring properties of atmospheric and climate data (data in space and time, multivariate data)
- Concepts of supervised learning (bias variance trade-off, overfitting, cross-validation)
- Advanced linear regression (multiple linear regression, regularization)
- Non-linear regression (tree based methods, neural networks)
- Un-supervised learning (dimension reduction, clustering)
- High-level applications of statistical learning for atmospheric and climate research (keynote speakers)

Literature

Prerequisites / notice
- Knowledge of introductory statistics
- Overview on the climate system
- Basic experience in a programming language

Course should be limited to 30 participants.

Exercises will be conducted in the R environment (https://www.r-project.org/), which is a specialized tool for statistical computing.

701-3001-00L Environmental Systems Data Science: Data Processing
- **Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.**
- Number of participants limited to 80.
- Course registration starts on 31.08.2022.
- Priority is given to the target groups until 23.09.2022.

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.
Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

### Numerical Modelling in Fortran

**Objective**
- The students are able to:
  - frame a data science problem and build a hypothesis
  - describe the steps of a typical data science project workflow
  - conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
  - critically think about the limits and implications of a method
  - visualise data and results throughout the workflow
  - access online resources to keep up with the latest data science methodology and deepen their understanding

**Content**
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

**Prerequisites / notice**
- Math IV, VI (Statistics); R, Python; ESDS I
- Prerequisite: 651-4273-00L Numerical Modelling in Fortran

**Waiting list will be deleted on 30.09.2022**

**Abstract**
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods.

**Objective**
- The students are able to:
  - select an appropriate model related to a research question and dataset
  - describe the steps from data preparation to running and evaluating models
  - prepare data for running machine learning with dependent and independent variable
  - build and validate regressions and neural network models
  - understand convolution and deep learning models
  - access online resources to keep up with the latest data science methodology and deepen their understanding

**Content**
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

**Literature**
Building on existing data science resources

**Taught competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>Media and Digital Technologies</td>
</tr>
<tr>
<td>assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
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</tbody>
</table>

**Prerequisites / notice**
- Math IV, VI (Statistics); R; Python; ESDS I
- Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

**Target groups**
- Agricultural Sciences PhD
- Environmental Sciences PhD
- Atmospheric and Climate Science MSc
- Environmental Sciences MSc
- Agricultural Sciences MSc
- Environmental Systems Data Science: Machine Learning

**Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.**

**Number of participants is limited to 80.**

Waiting list will be deleted on 30.09.2022

This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

**Abstract**
This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

**Prerequisites / notice**
- Prerequisite: 651-4273-00L Numerical Modelling in Fortran

**Waiting list will be deleted on 30.09.2022**

This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

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**Prerequisites / notice**
- Prerequisite: 651-4273-00L Numerical Modelling in Fortran

**Waiting list will be deleted on 30.09.2022**

This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

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This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

**Prerequisites / notice**
- Prerequisite: 651-4273-00L Numerical Modelling in Fortran
чивое вкладывание фотобиотических процессов в газовый баланс и влияние на температуру, потребление и продукцию. Образование и распад радиоактивных изотопов. Постепенно, это ведет к важным треккам изотопов и биомаркерам, их потенциал, методы и применение в биогеохимических процессах и региональных и глобальных масштабах.

Содержание

(i) Определение и биогеохимическое классификация треков элементов. (ii) Ключевые биогеохимические процессы, контролирующие циклы треков элементов, в природных и искусственных системах. (iii) Биотические и ионабиотические процессы, определяющие биохимические и экологические последствия треков элементов.

Лекции и заметки

Поставленные треки будут предоставлены для каждой темы.

Превентивные / Примечания

Ученики должны иметь базовое понимание биогеохимических процессов (BSc курс на биогеохимических процессах в водных системах или эквивалентном).

701-1315-00L Использование Треков Элементов в Экологии

Содержание

Коррекция содержания вкладывания фотобиотических процессов в газовый баланс и влияние на температуру, потребление и продукцию. Образование и распад радиоактивных изотопов. Постепенно, это ведет к важным треккам изотопов и биомаркерам, их потенциал, методы и применение в биогеохимических процессах и региональных и глобальных масштабах.

Содержание

(i) Определение и биогеохимическое классификация треков элементов. (ii) Ключевые биогеохимические процессы, контролирующие циклы треков элементов, в природных и искусственных системах. (iii) Биотические и ионабиотические процессы, определяющие биохимические и экологические последствия треков элементов.

Лекции и заметки

Поставленные треки будут предоставлены для каждой темы.

Превентивные / Примечания

Ученики должны иметь базовое понимание биогеохимических процессов (BSc курс на биогеохимических процессах в водных системах или эквивалентном).

701-1316-00L Натрий в Природных Средах

Содержание

(В) физика веществ в природных средах, с акцентом на транспорт, дисперсию, и смешение солей и прикрепленных частиц, и их роль в биологии и биогеохимических процессах.

Лекции и заметки

Поставленные треки будут предоставлены для каждой темы.

Превентивные / Примечания

Ученики должны иметь базовое понимание биогеохимических процессов и биохимии в природных и искусственных системах. (iii) Биотические и ионабиотические процессы, определяющие биохимические и экологические последствия треков элементов.

701-1346-00L Содержание Климатизации

Предварительные заметки

Учения и-аппеллированные, должны быть разосланы для вступительных занятий.

Превентивные / Примечания

Учения и-аппеллированные, должны быть разосланы для вступительных занятий.

701-1351-00L Альпакычный Пуд в Экологии

Содержание

Наличие и влияние на биохимические и биогеохимические процессы. Основные изотопы и биомаркеры, их потенциал, методы и применение в биогеохимических процессах и региональных и глобальных масштабах.

Превентивные / Примечания

Учения и-аппеллированные, должны быть разосланы для вступительных занятий.

701-1351-00L Альпакычный Пуд в Экологии

Содержание

Наличие и влияние на биохимические и биогеохимические процессы. Основные изотопы и биомаркеры, их потенциал, методы и применение в биогеохимических процессах и региональных и глобальных масштабах.

Превентивные / Примечания

Учения и-аппеллированные, должны быть разосланы для вступительных занятий.

701-1351-00L Альпакычный Пуд в Экологии

Содержание

Наличие и влияние на биохимические и биогеохимические процессы. Основные изотопы и биомаркеры, их потенциал, методы и применение в биогеохимических процессах и региональных и глобальных масштабах.

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Учения и-аппеллированные, должны быть разосланы для вступительных занятий.

701-1351-00L Альпакычный Пуд в Экологии

Содержание

Наличие и влияние на биохимические и биогеохимические процессы. Основные изотопы и биомаркеры, их потенциал, методы и применение в биогеохимических процессах и региональных и глобальных масштабах.

Превентивные / Примечания

Учения и-аппеллированные, должны быть разосланы для вступительных занятий.
Objective
- Successful application of knowledge gained in traditional disciplines of environmental sciences (e.g. biogeochemistry, environmental chemistry) to elucidate particle fate and behavior in the environment
- Identify key parameters that potentially influence the environmental fate and behavior of anthropogenic particles
- Get acquainted with the most common analytical tools for the quantification of anthropogenic particles in the environment
- Critical assessment of current state of research, including the sometimes controversial literature data

Content
- Definitions, particle types
- Particle behavior: colloidal behavior, transport, transformation
- Sources and release: Material flow modeling
- Fundamentals of particle analysis
- Release and emission
- Fate in the environment: water, soil, air
- Fate in technical systems: water treatment, waste incineration
- Uptake and toxicity of particles
- Environmental risk assessment
- Life cycle assessment

Lecture notes
Handouts will be provided

Literature
Selected handouts will be distributed during the course.

860-0012-00L  Cooperation and Conflict Over International Water Resources  W  3 credits  2G  T. Bernauer, T. U. Siegfried

Abstract
This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Objective
Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content
The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

20. Sep Global water challenges
27. Sep Nuts and bolts of hydrological modeling and what such models can tell us
04. Oct Nuts and bolts of hydrological modeling and what such models can tell us
11. Oct Water pollution and its mitigation
18. Oct Key challenges in international river systems
25. Oct Key challenges in international river systems
01. Nov Case study 1: Yarmuk
08. Nov Case study 2: Mekong
15. Nov Case study 3: Colorado
22. Nov Case study 4: Nile
29. Nov Case study 5: Central Asia
06. Dec Wrap up: what we can learn from these case studies
13. Dec Exam
20. Dec No class

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Lecture notes
Slides and reading materials will be made available via Moodle.

Literature
Slides and reading materials will be made available via Moodle.

Prerequisites / notice
The course is open to Master and doctoral students from any area of ETH.

Limited to 40 students.

Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.

Methods and Tools: Lab Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1331-00L</td>
<td>Biogeochemistry of Trace Elements Laboratory</td>
<td>W</td>
<td>3</td>
<td>4P</td>
<td>L. K. Thomas Arrigo, K. Barmettler</td>
</tr>
</tbody>
</table>

Abstract
The course offers a practical introduction into the investigation of the biogeochemistry of trace elements. Laboratory experiments are performed to study a selected environmental process. Advanced techniques for the analysis of total element contents and element speciation are used. The experimental findings are interpreted and discussed in their environmental context.

Objective
The objective of this course, is to offer students a practical introduction into the investigation of the biogeochemistry of trace elements. During the course, students will become familiar with some of the key experimental approaches typically used in the investigation of the biogeochemistry of trace elements in the laboratory. In addition, students will learn to use different advanced analytical techniques to measure the total content and the speciation of trace elements in both liquid and solid samples. The students will interpret and discuss their experimental findings in the context of the studied environmental system.

Content
Laboratory experiments are designed and performed to study the interplay of various biogeochemical processes in a specific environmental system. Moreover, the effect of these processes on the biogeochemical cycling of trace elements in the environment will be considered. Advanced techniques for the analysis of total element contents and element speciation are used. The experimental findings are interpreted and discussed in the context of the the environmental system under investigation.

Lecture notes
Selected handouts will be distributed during the course.
The main part of the course is the investigation of real samples of soils/sediments in the lab working in groups. A brief theoretical introduction into the overall principle and the meaning of physical, mineralogical and chemical parameters of soils and sediments and into each analytical method for their investigation will be given in advance. The competencies of process understanding, system understanding, concept development, and measurement methods are taught and assessed.

Content

Basic introduction to mineralogy and texture of soils
Analytical techniques
Practical exercises in sample preparation
Measurement and evaluation of the data:
- physical parameters (grain size distribution, surface, densities, porosity, (micro)structur)
- mineralogical/geochemical parameters (quantitative mineralogical composition, thermal analysis, cation exchange etc.)

Lecture notes
Selected handouts will be distributed during the course.

Literature

Prerequisites / notice
Useful preparatory courses are: "Soil Chemistry", "Clays in Geotechnics", and "X-ray powder diffraction".

Waiting list will be deleted 22.09.2022.
Number of participants limited to 12.
Number of participants limited to 24.
The ability to critically evaluate original (scientific) literature and to summarise the information in a succinct manner is an important skill for

Lecture material will be online for registered students using moodle

Each student presents the results of their term paper to fellow students and advisors and responds to questions and comments from the

The goal of the term paper is to train the student's ability to critically evaluate scientific literature and to summarise the findings concisely in

Term Paper 2: Seminar

Prerequisite: Term Paper 1: Writing (701-1303-00L).

Only for Environmental Sciences MSc and Science, Technology and Policy MSc.

Week 2: Lecture on Measurement Science, overview of water content and water potential sensors; data logging and data logger programming; tests in the lab

Week 3: Introduction on soil physics; Field installation of sensors and field experiment; data collection for a few days; solar panel

Week 4: Soil sampling in field lab including geoprobe measurements

Week 5: Introduction on forest lab - Soil sampling in forest lab; root length density;

Week 6: Lecture on geophysical methods on Subsurface Characterization: Basic principles of ERT, GPR, and EM; simple lab tests on effective resistivity

Week 7: Demonstration and application of geophysical methods in the field

Week 8: Lecture on plant soil relationship: connecting information below and above ground – data analysis

Weeks 9 and 10: Forest characterization/ inventory: Principles of LiDAR; structures and features of the tree crowns, size/volume of the leaf area tree positions and diameters at breast height

Weeks 11 and 12: Eddy covariance methods -Principles of field measurement of water vapor, carbon dioxide, and energy exchange between terrestrial surfaces and the atmosphere; Analysis of measured time series to determine evaporation rate and CO2-fluxes

Week 13: Swiss Soil Monitoring networks – Monitoring of soil water content and potential; climate change and droughts

Week 14: Global data – Global modeling and data interpretation; SoilGrids and OpenLandMap; exercises on Budyko analysis

The details of the schedule will be optimized based on the number of students; some blocks of the course will be offered as well to students of Environmental Engineering

The students will be able to:
- explain measurement principles that are used for characterization of landscapes and terrestrial systems
- select appropriate measurement methods and sampling design to quantify key variables and processes above ground and in the subsurface
- deploy sensors in the field
- interpret collected laboratory and field data and report main conclusions deduced from measurements

The students will be able to:
- narrow down a research question.
- identify relevant literature to address the research question.
- concisely summarise and critically evaluate their findings.
- formulate key outstanding questions.

This is the 2nd part of a series and participation is conditional on the successful completion of "Term Paper 1: Writing". The results from the term paper written during the previous term are presented to the other students and advisors and discussed with the audience.

The goal of the term paper seminars is to train the student's ability to communicate (scientific) results to a wider audience and the ability to 

There is no final exam. Grade is assigned based on the quality of the presentation and ensuing discussion.

To obtain the credits, it is mandatory to attend at least 60% of all seminar dates offered in the fall and spring semester. Active participation in discussion and feedback rounds is expected.
Each student is expected to write a paper with a length of approximately 15-20 pages. The students can choose from a list of topics prepared by the tutors, but the final topic will be determined based on a balance of choice and availability. The students will be guided and advised by their tutors throughout the term.

The paper itself should contain the following elements:
- Motivation and context of the given topic (25%)
- Concise presentation and critical evaluation of the state of the science (50%)
- Identification of open questions and perhaps opportunities for further research (25%)

In addition, the accurate use of citations, attribution of ideas, and the judicious use of figures, tables, equations and references are critical components of a successful paper. Specialised knowledge is not expected, nor required; neither is new research.

Lecture notes
Guidelines and supplementary material are distributed on the Moodle platform.

Literature
Original scientific literature will be identified based on the chosen topic.

Prerequisites / notice
Please enrol latest until the first week of the semester. Contact termpaper(at)env.ethz.ch if you don't yet have access to MyStudies.

The term paper course is primarily aimed at master students majoring in biogeochemistry & pollutant dynamics and ISTP students with a solid background in natural sciences and a strong interest in biogeochemistry & pollutant dynamics.

Each student submits a term paper that will be reviewed by one fellow student and one faculty. The submission of the term paper and a written review of another student's term paper are a condition for obtaining the credit points.

There is no final exam. The grade is assigned based on the quality of the term paper and the submitted review as well as on the presentation in the following term.

Results from the term paper will be presented to fellow students and involved faculty in the following semester ("Term Paper 2: Seminar").

### Electives

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>701-3001-00L</td>
<td>Environmental Systems Data Science: Data Processing</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne, M. Volpi</td>
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<tr>
<td></td>
<td><strong>Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.</strong></td>
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</table>

Number of participants is limited to 80.

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
- 252-0840-02L Anwendungsnahe Programmieren mit Python
- 401-0624-00L Mathematik IV: Statistik
- 401-6215-00L Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

701-3003-00L | Environmental Systems Data Science: Machine Learning | W    | 3 credits | 2G   | L. Pellissier, E. J. Harris, J. Payne, M. Volpi |
| Number       |                                                        |      |      |       |                         |

Number of participants is limited to 80.

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022
Abstract
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning model

Objective
The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature
Building on existing data science resources
Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

Major in Ecology and Evolution

A. Fundamentals

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0328-00L</td>
<td>Advanced Ecological Processes</td>
<td>W</td>
<td>4 credits</td>
<td>2V</td>
<td>J. Hille Ris Lambers</td>
</tr>
</tbody>
</table>

Abstract
This course presents theoretical and empirical approaches to understanding the ecological processes structuring populations and communities. Central problems covered include species interactions, spatial structure, resource dynamics, and ecological responses to environmental change. These and other topics will be explored from basic and applied perspectives.

Objective
Students will understand how ecological processes operate in natural communities. They will appreciate how mathematical theory, field experimentation, and observational studies combine to generate a predictive science of ecological processes, and how this predictive science informs conservation and management decisions.

Upon completing the course, students will be able to:

Understand the factors determining the outcome of species interactions in communities, and how this information informs management.

Apply theoretical knowledge on species interactions to predict the potential outcomes of novel species introductions.

Understanding the role of spatial structure in mediating population dynamics and persistence, species interactions, and patterns of species diversity.

Use population and community models to predict the stability of interactions between predators and prey and between different competitors.

Understand the conceptual basis of predictions concerning how ecological communities will respond to global change.

Discuss the types of conceptual advances ecology as a science can realistically achieve, and how these relate to the applications of the discipline.

Content
Lectures supplemented with readings from the primary literature and occasional computer exercises will focus on understanding central processes in community ecology. Topics will include demographic and spatial structure, consumer resource interactions, food webs, competition, mutualism, invasion, the maintenance of species diversity, and species effects on ecosystem processes. Each of these more conceptual topics will be discussed in concert with their applications to the conservation and management of species and communities in a changing world.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Autumn Semester 2022
Advanced Concept Classes

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
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</tbody>
</table>

**Abstract**
Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

**Objective**
This is an advanced course that will require significant student participation. Students will learn to how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

**Content**
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

**Lecture notes**
Publications and class notes can be downloaded from a web page announced during the lecture.

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-1409-00L</td>
<td>Research Seminar: Ecological Genetics</td>
<td>W</td>
<td>2 credits</td>
<td>1S</td>
<td>S. Flor</td>
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</tbody>
</table>

**Abstract**
In this research seminar we will critically discuss recent publications on current topics in Ecological Genetics.

**Objective**
It is our aim that participants gain insight into current research topics and approaches in Ecological Genetics and learn to critically assess and appreciate scientific publications in this field.

**Lecture notes**
Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. 

**Prerequisites / notice**
It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-1471-00L</td>
<td>Ecological Parasitology</td>
<td>W</td>
<td>3 credits</td>
<td>1V+1P</td>
<td>J. Jokela, C. Vorburer</td>
</tr>
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</table>

**Abstract**
Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

**Objective**
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

**Content**
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

**Prerequisites / notice**
The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

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<tr>
<td>701-1676-01L</td>
<td>Genomics of Environmental Adaptation</td>
<td>W</td>
<td>2 credits</td>
<td>3G</td>
<td>R. Holderegger, F. Gugerli, C. Rellstab</td>
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</table>

**Abstract**
This five-day winter school aims at teaching advanced Master students, PhD students and postdoctoral researchers on aspects of the genomics of environmental adaptation. It provides both theoretical background and hands-on exercises on major topics of contemporary environmental genomics such as signatures of selection, outlier analysis, environmental association analysis or GWAS.

**Objective**
Genomics of environmental adaptation is an evolving scientific field of both basic and applied interest. Researchers make increasing use of diverse methodological approaches built on concepts from ecology, evolutionary biology and population genomics. This winter school introduces students to some major concepts and methods of environmental genomics, i.e., (i) how the environment and adaptive genetic variation relate and (ii) how signatures of genomic adaptation can be detected in natural populations. The winter school focuses on currently used methods and hands-on exercises, emphasizing an understanding of the underlying concepts and a discussion of benefits, limitations and pitfalls of environmental genomics. It is specifically aimed at the needs of advanced Master students, PhD students and early postdoctoral researchers.

**Content**
Topics:
1. Neutral and adaptive genetic variation, neutral genetic structure; genomic markers and next generation sequencing techniques.
2. Outlier analysis: concept and methodology of outlier analysis; diverse types of outlier analyses
3. Environmental data: which environmental data are available and used to identify signatures of adaptation; data limitations; collinearity.
4. Environmental association analysis (landscape genomics): concept and types of environmental association analysis; genomic offset.
5. Genotypes and phenotypes: GWAS; follow-up analyses

**Lecture notes**
Hand-outs will be distributed.

**Literature**
The course requires 4 hours of preparatory reading of selected papers on the genomics of environmental adaptation. The papers will be distributed by e-mail.

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Waiting list will be deleted 19.01.2023.

Waiting list will be deleted on 30.09.2022.

Waiting list will be deleted 19.01.2023.

Waiting list will be deleted 24.01.2023.

Waiting list will be deleted 19.01.2023.

Waiting list will be deleted 19.01.2023.

Waiting list will be deleted 19.01.2023.

Waiting list will be deleted 19.01.2023.

Waiting list will be deleted 19.01.2023.

Waiting list will be deleted 19.01.2023.
A. Hall

The focus is on primary literature, but for some parts the following text books provide good background information:

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) evolutionary medicine for infectious diseases, (ii) evolutionary thinking in the context of infectious diseases, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature

The focus is on primary literature, but for some parts the following text books provide good background information:

701-1703-00L Evolutionary Medicine for Infectious Diseases W 3 credits 2G A. Hall

Waiting list will be deleted 02.10.2022.

Abstract

This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective

Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature

The focus is on primary literature, but for some parts the following text books provide good background information:

Schmid Hempel 2011 Evolutionary Parasitology

Steams & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

636-0017-00L Biogeography and Sustainable Management W 2 credits 2G A. Hall

This course focuses on the interactions between ecology, biogeography and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems. Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems. Responses of agroecosystems to the environment, i.e., to climate and climate change, will be studied. Different meteorological and greenhouse gas flux data will be analysed using R and assessed in terms of production, greenhouse gas budgets and carbon sequestration. Thus, students will learn about the complex interactions of a coupled human-environmental system.

Students will work with real-life data from the long-term measurement network Swiss FluxNet. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSEE students, we highly recommend the voluntary course ‘Introduction to Programming’, which takes place in Basel before the start of the semester.

Lecture notes

Lecture slides will be available on moodle.

Number of participants limited to 35.

Autumn Semester 2022

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Lecture notes
Handouts will be available in moodle.

Prerequisites / notice
Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Personal Competencies
Critical Thinking assessed
Self-direction and Self-management not assessed

Applications

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<tr>
<th>Number</th>
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<tr>
<td>701-1453-00L</td>
<td>Ecological Assessment and Evaluation</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>F. Knaus</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.</td>
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<td><strong>Objective</strong></td>
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<td>Students will be able to:</td>
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<td>1) critically consider biological data books and local, regional, and national inventories; 2) evaluate the validity of ecological criteria used in decision making processes; 3) critically appraise the handling of ecological data and criteria used in the process of evaluation 4) perform an ecological evaluation project from the field survey up to the decision making and planning.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Powerpoint slides are available on the webpage. Additional documents are handed out as copies.</td>
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<td><strong>Literature</strong></td>
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<td>Basic literature and references are listed on the webpage.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.</td>
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<tr>
<td>701-1613-01L</td>
<td>Advanced Landscape Research</td>
<td>W</td>
<td>5 credits</td>
<td>3G</td>
<td>L. Pellissier, U. Gimmi, M. Hunziker</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>This course introduces landscapes as socially perceived, spatially and temporally dynamic entities that are shaped by natural and societal factors. Concepts and qualitative and quantitative methods to study landscapes from an ecological, societal and historical perspective are presented. In a term paper students work on a landscape-related topic of their choice.</td>
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<td><strong>Objective</strong></td>
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<td>Students will:</td>
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</table>
|          | - learn about concepts and methods to quantify structural and functional connectivity in landscapes, particularly  
|          | - be introduced to the topic of landscape genetics and its benefits and (current) limitations for applied conservation  
|          | - learn about concepts and methods in scenario-based land-use change modelling  
|          | - approach an understanding of landscape as perceived environment  
|          | - learn about concepts of landscape preference and related measurement methods  
|          | - be introduced into approaches of actively influencing attitudes and behavior as well as related scientific evaluation  
|          | - make use of various historical sources to study landscapes and their dynamics  
|          | - interpret landscapes as a result of ecological constraints and anthropogenic activities. |
|          | **Content**                   |      |      |       |                          |
|          | 1. Encompassing concepts and approaches  
|          | - European Landscape Convention (ELC)  
|          | - Ecosystem Services (ES): introduction and critical evaluation  
|          | **Thematic topics**           |      |      |       |                          |
|          | 2. Ecological approach:  
|          | - green infrastructure (e.g., ecological conservation areas)  
|          | - landscape connectivity  
|          | - landscape genetics and management applications  
|          | - concepts of specific quantitative methods: least cost paths, resistance surfaces, Circuitscape, networks (Conefor), land-use change models, various statistical methods  
|          | 3. Social-science approach:  
|          | - principle of landscape as perceived and connoted environment  
|          | - theories on landscape preference and place identity  
|          | - role of landscapes for recreation, health and well-being  
|          | - intervention approaches for influencing attitudes and related behavior  
|          | - methods of investigating the landscape-landscape relationship and evaluating interventions  
|          | 4. Historical approach:  
|          | - land use history of Switzerland (agricultural history, forest and woodland history)  
|          | - historical legacies of land use in landscapes and ecosystems  
|          | - historic-ecological approaches and applications  
|          | 5. Land change science:  
|          | - modelling future land-use (CLUE, other scenario-based models)  
|          | - landscape functions and services  
|          | **Lecture notes**             |      |      |       |                          |
|          | Handouts will be available in the course and for download |
|          | **Prerequisites / notice**    |      |      |       |                          |
|          | Basic Landscape Ecology courses at Bachelor level |

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-1631-00L</td>
<td>Foundations of Ecosystem Management</td>
<td>W</td>
<td>5 credits</td>
<td>3G</td>
<td>J. Ghazoul, A. Giger Dray</td>
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<td><strong>Number of participants is limited to 35.</strong></td>
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<td><strong>Priority is given to the target groups until 26.09.2022,</strong></td>
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</table>
This course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

Students will:
- be enabled to understand and evaluate the fundamental properties of dynamic systems using vegetation models as case studies
- obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level
- understand and work with the basic assumptions of various model types, which dictate the applicability and limitations of the respective model
- be enabled to work with such model types on their own
- appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.

Content
- Models of individuals
  - Deriving single-plant models from inventory measurements
  - Plant models based on ‘first principles’
- Models at the stand scale
  - Simple approaches: matrix models
  - Competition for light and other resources as central mechanisms
  - Individual-based stand models: distance-dependent and distance-independent
  - Theoretical models
- Models at the landscape scale
  - Simple approaches: cellular automata
  - Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
  - Landscape models
- Global models
  - Sacrificing local detail to attain global coverage: processes and entities
  - Dynamic Global Vegetation Models (DGVMs)
  - DGVMs as components of Earth System Models

Lecture notes
Handouts will be available in the course and for download

Literature
Will be indicated at the beginning of the course

Prerequisites / notice
- Ideally basic experiences in modelling and systems analysis
- Basic knowledge of programming, ideally in R
- Good knowledge of general ecology, ideally of vegetation dynamics and forest systems

701-1679-00L Landscape Modelling of Biodiversity: From Global to Local

Abstract
The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

Students will:
- be enabled to understand and evaluate the fundamental properties of dynamic systems using vegetation models as case studies
- obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level
- understand and work with the basic assumptions of various model types, which dictate the applicability and limitations of the respective model
- be enabled to work with such model types on their own
- appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.

Content
- Models of individuals
  - Deriving single-plant models from inventory measurements
  - Plant models based on ‘first principles’
- Models at the stand scale
  - Simple approaches: matrix models
  - Competition for light and other resources as central mechanisms
  - Individual-based stand models: distance-dependent and distance-independent
  - Theoretical models
- Models at the landscape scale
  - Simple approaches: cellular automata
  - Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
  - Landscape models
- Global models
  - Sacrificing local detail to attain global coverage: processes and entities
  - Dynamic Global Vegetation Models (DGVMs)
  - DGVMs as components of Earth System Models

Lecture notes
Handouts will be available in the course and for download

Literature
Will be indicated at the beginning of the course

Prerequisites / notice
- Ideally basic experiences in modelling and systems analysis
- Basic knowledge of programming, ideally in R
- Good knowledge of general ecology, ideally of vegetation dynamics and forest systems

701-1677-00L Quantitative Vegetation Dynamics: Models from Tree to Globe

Abstract
The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

Students will:
- be enabled to understand and evaluate the fundamental properties of dynamic systems using vegetation models as case studies
- obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level
- understand and work with the basic assumptions of various model types, which dictate the applicability and limitations of the respective model
- be enabled to work with such model types on their own
- appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.

Content
- Models of individuals
  - Deriving single-plant models from inventory measurements
  - Plant models based on ‘first principles’
- Models at the stand scale
  - Simple approaches: matrix models
  - Competition for light and other resources as central mechanisms
  - Individual-based stand models: distance-dependent and distance-independent
  - Theoretical models
- Models at the landscape scale
  - Simple approaches: cellular automata
  - Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
  - Landscape models
- Global models
  - Sacrificing local detail to attain global coverage: processes and entities
  - Dynamic Global Vegetation Models (DGVMs)
  - DGVMs as components of Earth System Models

Lecture notes
Handouts will be available in the course and for download

Literature
Will be indicated at the beginning of the course

Prerequisites / notice
- Ideally basic experiences in modelling and systems analysis
- Basic knowledge of programming, ideally in R
- Good knowledge of general ecology, ideally of vegetation dynamics and forest systems
Aquatic Ecology II

During this course you will get an overview of the world's typical freshwater ecosystems. After this course you will be able to understand

A. M. Minder Pfyl

This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with

3V

Students learn:

- Theoretical foundations of the species ecological niche
- Biodiversity concepts and global change impacts
- Basic concepts of spatial (and macro-) ecology
- Environmental impact assessment and planning
- Advanced statistical methods (GLM, GAM, CART) and basic programming (loops, functions, advanced scripting) in the statistical environment R.
- The use of GIS functionality in R

1. The basics:
   - Introduction to the concept of the ecological niche, and biodiversity theories. Overview of the knowledge on expected biodiversity response
   - to global changes and conservation planning methods.
   - Introduction to the statistical methods of Generalized Linear (GLM) and Generalized Additive models (GAM), and Classification
   - and Regression Trees (CART). Introduction to basic GIS and programming elements in the statistical environment R.

2. The class project:
   - Students form groups of two, and each group solves a series of applied questions independently in R using the techniques taught in the
   - introductory classes. The students then prepare a presentation and report of the obtained results that will be discussed during a mini-
   - symposium. Each team chooses one of the following topics for the class project:
   - a) Linking climate change velocities to species' migration capacities
   - b) Explaining and modelling land use change in Switzerland
   - c) Explaining and modelling biodiversity changes in Switzerland
   - d) Designing biodiversity conservation strategies under global changes.

Prerequisites / notice

Basic knowledge in statistics (OLS regression, test statistics), and basic knowledge in geographic information science.

Laboratory and Field Expertise

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1425-01L</td>
<td>Genetic Diversity: Techniques</td>
<td>W</td>
<td>2 credits</td>
<td>4P</td>
<td>A. M. Minder Pfyl</td>
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<td></td>
<td>Number of participants limited to 8.</td>
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<tr>
<td>Abstract</td>
<td>This course provides laboratory training for advanced students (master, doctoral or post-doctoral level). Different DNA/RNA extraction protocols, quality control measurements, SNP genotyping and gene expression techniques will be addressed. This is a course for practitioners.</td>
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<tr>
<td>Objective</td>
<td>To learn and improve on standard and modern methods of genetic data collection. With a focus on: Use of different extractions protocols, techniques for quality control measurements, gene expression, pyrosequencing and other SNP genotyping techniques.</td>
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<tr>
<td>Content</td>
<td>After an introduction (one afternoon), students have 3 weeks to work independently in groups of two on different protocols. At the end of this practical part, the whole class meets for another afternoon to present the techniques/results and to discuss the advantages and disadvantages of the different techniques. Techniques addressed are: RNA/DNA extractions and quality control, SNP genotyping, pyrosequencing, real-time qPCR.</td>
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<tr>
<td>Lecture notes</td>
<td>Material will be handed out in the course.</td>
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<tr>
<td>Literature</td>
<td>Material will be handed out in the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Two hours are held in the class. The lab work will be done from the students according to their timetable, but has to be finished after 3 weeks. Effort is roughly 1-2 full days per week, depending on the skills of the student.</td>
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<th>Number</th>
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<tbody>
<tr>
<td>701-1437-00L</td>
<td>Aquatic Ecology I</td>
<td>W</td>
<td>3 credits</td>
<td>3V</td>
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<tr>
<td>Abstract</td>
<td>This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, groundwater and lakes.</td>
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<tr>
<td>Objective</td>
<td>During this course you will get an overview of the world's typical freshwater ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat and how the interactions (e.g. food web) between organisms work. In short: apply the theoretical / lecture knowledge to field situations in a lake and river.</td>
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<tr>
<td>Content</td>
<td>The lectures cover ecology and evolution of aquatic organisms in lentic and lotic waters. Topics include: Adaptations, distribution patterns, biotic interactions, and conceptual paradigms in freshwater ecosystems. Important aspects regarding ecosystem metabolism and habitat properties of freshwater. Applied case studies and experiments testing ecological and evolutionary processes in freshwater ecosystems. The lectures are given by Piet Spaak (Eawag), Florian Altermatt (UNI, Eawag), Chris Robinson (Eawag), Francesco Pomati (Eawag), Anita Narwani (Eawag) and specialists from the Aquatic Ecology department of Eawag and University of Zurich.</td>
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<tr>
<td>Lecture notes</td>
<td>Course notes and power point presentations provided during the course.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>701-1437-03L</td>
<td>Aquatic Ecology II</td>
<td>W</td>
<td>5 credits</td>
<td>6U</td>
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<tr>
<td>Abstract</td>
<td>This course builds on Aquatic Ecology I and cannot be taken separately. It aims on extending the covered concepts and apply them to natural and experimental systems. The course contains research projects, a 1-day excursion to a lake as well as a 3-day excursion to a river.</td>
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Autumn Semester 2022

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The taxonomic part will cover microinvertebrates and freshwater algae. The goal is to get to know the most common aquatic taxa in Switzerland. During this course you will get an overview of the typical aquatic microinvertebrates and algae in Switzerland. After this course you will be able to identify the most important aquatic species groups at the level of order/family and know the most important identification traits. You will also be able to use identification literature commonly used in Switzerland. During an excursion, you will apply the theoretical identification knowledge to field situations.

**Objective**

After this course you will be able to identify the most important aquatic species groups at the level of order/family and know the most important identification traits. You will also be able to use identification literature commonly used in Switzerland.

**Abstract**

This course gives an overview of the typical aquatic microinvertebrate and freshwater algae groups in Switzerland. Beside a theoretical background on the different groups the focus is laid on the determination of the most important species groups and their identification traits, also using identification keys. Practical experience in benthic sampling techniques is collected during an excursion.

**Content**

The taxonomic part will cover macroinvertebrates (e.g. Crustacean, aquatic insects). The goal is to get to know the most common aquatic taxa in Switzerland, to identify them with commonly used identification literature, and to get an idea how these organisms are used in research and practice. (language: German, translation of the most important things during the course possible).

**Lecture notes**

Course notes and power point presentations provided during the course.

**Prerequisites / notice**

The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I", "701-1437-03 Aquatic Ecology II" and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" are given priority. Sign in until 15.08.2022, free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.

During the research project you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work). You will present the collected knowledge and write a report about it.

During the excursions you will get to know a lake system as well as a river system. The main goal of the excursions is that the students as a team conduct their own field research project and collect data in the field.

The field excursions contain a 1-day excursion to a lake (Greifensee) and a 3-day excursion to a river (Glatt, Niederuzwil). The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL (ETH & UNI). Registration for the course until 15.08.2022, free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.

The field excursion takes place Tuesday afternoon 25.10.2022 from 1pm-5pm.

The excursion includes a mandatory field trip to Greifensee (22.09.2022) and a three-day excursion to the river Glatt (28.-30.09. 2022).

**Objective**

The excursion takes place Thursday 20.10.2022 from 1pm-5pm.

**Abstract**

This course gives an overview of the typical aquatic microinvertebrate and freshwater algae groups in Switzerland. Beside a theoretical background on the different groups the focus is laid on the recognition of the most important species groups and their identification traits. Practical experience is collected during an excursion.

**Content**

The excursions take place Thursday 20.10.2022 from 1pm-5pm.

**Lecture notes**

Course notes and power point presentations provided during the course.

**Prerequisites / notice**

The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I", "701-1437-03 Aquatic Ecology II" and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" are given priority. Sign in until 15.08.2022, free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.

The field excursion takes place Tuesday afternoon 25.10.2022 from 1pm-5pm.

**Objective**

The field excursion takes place Thursday afternoon 20.10.2022 from 1pm-5pm.

**Abstract**

This course gives an overview of the typical aquatic macroinvertebrate groups in Switzerland. Beside a theoretical background on the different groups the focus is laid on the determination of the most important species groups and their identification traits, also using identification keys. Practical experience in benthic sampling techniques is collected during an excursion.

**Content**

The field excursion takes place Tuesday 25.10.2022.

**Lecture notes**

Course notes and power point presentations provided during the course.

**Prerequisites / notice**

The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I", "701-1437-03 Aquatic Ecology II" and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" are given priority. Sign in until 15.08.2022, free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.

The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL (ETH & UNI). Registration for the course until 15.08.2022, free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.

**Objective**

During the research project you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work). You will present the collected knowledge and write a report about it.

During the excursions you will get to know a lake system as well as a river system. The main goal of the excursions is that the students as a team conduct their own field research project and collect data in the field.

The field excursions contain a 1-day excursion to a lake (Greifensee) and a 3-day excursion to a river (Glatt, Niederuzwil). The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I", "701-1437-03 Aquatic Ecology II" and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" and "701-1437-02 Bestimmungskurs Süsswasseragen und aquatische Mikroinvertebraten". The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL (ETH & UNI). Registration for the course until 15.08.2022, free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.
Abstract
Individual writing of an essay-type review paper about a specialized topic in the field of ecology and evolution, based on substantial reading of original literature and discussions with a senior scientist.

Objective
- Students acquire a thorough knowledge on a topic in which they are particularly interested
- They learn to assess the relevance of original literature and synthesize information
- They make the experience of becoming "experts" on a topic and develop their own perspective
- They practise academic writing according to professional standards in English

Content
Topics for the essays are proposed by the professors and lecturers of the major in Ecology and Evolution at a joint meeting at the beginning of the semester (the date will be communicated by e-mail to registered students).

Students will:
- choose a topic
- search and read appropriate literature
- develop a personal view on the topic and structure their arguments
- prepare figures and tables to represent ideas or illustrate them with examples
- write a clear, logical and well-structured text
- refine the text and present the paper according to professional standards

Lecture notes
In all steps, they will benefit from the advice and detailed feedback given by a senior scientist acting as personal tutor of the student.

Prerequisites / notice
The "Term Paper" requires considerable time set aside to read and digest original scientific literature, culminating in the writing of a review paper. The submission deadline is the first day of the spring semester, implying that much of the actual writing will be performed in January and February. Grading is based on the quality of the submitted review paper (2/3 of total grade), and on the "soft skills" such as the level of initiative, timeliness, independence, etc. of the student (1/3 of total grade). The personal supervisor is charged with grading the student's performance.

Electives

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0290-00L</td>
<td>Seminar in Microbial Evolution and Ecology (HS)</td>
<td>Z</td>
<td>0</td>
<td>2S</td>
<td>L. Bonhoeffer</td>
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</tbody>
</table>

Seminar of the groups Molecular Microbial Ecology, Theoretical Biology, Experimental Ecology, Evolutionary Biology. Talks given by members of these groups and external visitors.

Objective
In-depth introduction into microbial evolution and ecology, especially the aspects that are the focus of on-going research in this area at Department of Environmental Systems Science.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-3001-00L</td>
<td>Environmental Systems Data Science: Data Processing</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne, M. Volpi</td>
</tr>
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</table>

**Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.**

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-3003-00L</td>
<td>Environmental Systems Data Science: Machine Learning</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne, M. Volpi</td>
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</table>

Number of participants is limited to 80.

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning models.

Objective
The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature
Building on existing data science resources

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

551-0205-00L Challenges in Plant Sciences
Number of participants limited to 40.

Abstract
The colloquium “Challenges in Plant Sciences” is a core class of the Zurich-Basel Plant Science Center’s PhD program and the MSc module. The colloquium introduces participants to the broad spectrum of plant sciences within the network. The course offers the opportunity to approach interdisciplinary topics in the field of plant sciences.

Objective
Objectives of the colloquium are:
- Introduction to recent research in all fields of plant sciences
- Working in interdisciplinary teams on the topics
- Developing presentation and discussion skills

Content
The topics encompass integrated knowledge on current plant research, ranging from the molecular level to the ecosystem level, and from basic to applied science while making use of the synergies between the different research groups within the PSC.

More information on the content: https://www.plantsciences.uzh.ch/en/teaching/masters/colloquium.html

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Social Competencies
Communication assessed
Personal Competencies
Cooperation and Teamwork not assessed
Self-direction and Self-management not assessed

751-4504-00L Plant Pathology I

Abstract
Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.

Objective
Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytoalexins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes  Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

Major in Environmental Systems Policy

Theoretical Foundations for Environmental Policy

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<tr>
<td>701-1563-00L</td>
<td>Climate Policy</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>A. Patt, S. Hanger-Kopp</td>
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This course provides an in-depth analysis both of the theoretical underpinnings to different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

This course is about all that. The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

There will be daily reading assignments, which we will then discuss critically during the class sessions. All of these will be posted in PDF format on a course Moodle. In addition, there will be two books to be read over the course of the semester. Both of these can be accessed from the ETH library or in PDF form free of charge. They are:


### Taught competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td>Assessed</td>
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### Literature


### Objective

- To analyze the evolution as well as the key elements of environmental governance.
- To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

### Content

- Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors’ behavior and can occur at the local, regional, national or international level.

- In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

### Key questions that this course seeks to answer:

- What are the core characteristics of environmental challenges from a policy perspective?
- What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?
The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Content
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Reading materials and slides will be available via Moodle. This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Title: Modeling and Statistical Analysis

Number: 860-0023-00L

Type: W

ECTS: 3

Hours: 2

Lecturers: T. Bernauer

Does not take place this semester.

Particularly suited for students of D-ITET, D-USYS

Abstract: This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

Objective
The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

Content
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Reading materials and slides will be available via Moodle. This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.
701-1453-00L

Ecological Assessment and Evaluation

Abstract
The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

Objective
Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Lecture notes
Powerpoint slides are available on the webpage. Additional documents are handed out as copies.

Literature
Basic literature and references are listed on the webpage.

Prerequisites / notice
Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

701-1565-00L

Quantitative Policy Analysis and Modeling

Abstract
The lectures will introduce students to the principles of quantitative policy analysis, namely the methods to predict and evaluate the social, economic, and environmental effects of alternative strategies to achieve public objectives. A series of individual assignments, and one group project, will give students an opportunity for students to apply those methods to a set of case studies.

Objective
The objectives of this course are to develop the following key skills necessary for policy analysts:
- Developing conceptual models of the types of processes and relationships governing these quantitative factors, including stock-flow dynamics, feedback loops, optimization, sources and effects of uncertainty, and agent coordination problems.
- Developing and program numerical models to simulate the processes and relationships, in order to identify policy problems and the effects of policy interventions.
- Communicate the findings from these simulations and associated analysis in a manner that makes transparent their theoretical foundation, the level and sources of uncertainty, and ultimately their applicability to the policy problem.

Content
The course will proceed through a series of policy analysis and modeling exercises, involving real-world or hypothetical problems. The specific examples around which work will be done will concern the environment, energy, health, and natural hazards management.

Prerequisites / notice
Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

101-0491-00L

Agent Based Modeling in Transportation

Abstract
This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

Objective
At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform practical transportation studies

Content
This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:
1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

Literature
Agent-based modeling in general
MATSim

Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

Prerequisites / notice
There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

363-0541-00L

Systems Dynamics and Complexity

Abstract
The course will proceed through a series of policy analysis and modeling exercises, involving real-world or hypothetical problems. The specific examples around which work will be done will concern the environment, energy, health, and natural hazards management.

Objective
The objectives of this course are to develop the following key skills necessary for policy analysts:
- Developing conceptual models of the types of processes and relationships governing these quantitative factors, including stock-flow dynamics, feedback loops, optimization, sources and effects of uncertainty, and agent coordination problems.
- Developing and program numerical models to simulate the processes and relationships, in order to identify policy problems and the effects of policy interventions.
- Communicate the findings from these simulations and associated analysis in a manner that makes transparent their theoretical foundation, the level and sources of uncertainty, and ultimately their applicability to the policy problem.

Content
This course will proceed through a series of policy analysis and modeling exercises, involving real-world or hypothetical problems. The specific examples around which work will be done will concern the environment, energy, health, and natural hazards management.

Prerequisites / notice
Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie
At the end of the course, students:

- Climate Policy

P. Krütli

Selected scientific articles and book-chapters

Communication

D. Nef

This course provides an in-depth analysis both of the theoretical underpinnings to different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise these frameworks critically.

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamic models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Lecture notes

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

Mike

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2203 of 2345
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures.” With interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

This course is about all that. The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

There will be daily reading assignments, which we will then discuss critically during the class sessions. All of these will be posted in PDF format on a course Moodle. In addition, there will be two books to be read over the course of the semester. Both of these can be accessed from the ETH library or in PDF form free of charge. They are:

The Climate Casino, by William Nordhaus. Yale University Press.


### Key challenges in international river systems

- Water pollution and its mitigation
- Global water challenges
- Nuts and bolts of hydrological modeling and what such models can tell us
- Water pollution and its mitigation
- Global water challenges

### Literature


### Taught competencies

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: not assessed
- **Method-specific Competencies**
  - Communication: not assessed
  - Negotiation: not assessed
- **Social Competencies**
  - Critical Thinking: assessed

### Course Information

- **Code**: 860-0012-00L
- **Name**: Cooperation and Conflict Over International Water Resources
- **Priority**: for Science, Technology, and Policy MSc.
- **Number of participants limited to 40.

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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2204 of 2345
Lecture notes
Slides and reading materials will be made available via Moodle.

Literature
Slides and reading materials will be made available via Moodle.

Prerequisites / notice
The course is open to Master and doctoral students from any area of ETH. Limited to 40 students.

Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.

Electives

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>701-3001-00L</td>
<td>Environmental Systems Data Science: Data Processing</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne, M. Volpi</td>
</tr>
<tr>
<td></td>
<td><em>Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.</em></td>
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</table>

Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022,

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning

Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022,

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning models.

Objective
The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions
Major in Forest and Landscape Management

Natural Science Foundations

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-1613-01L</td>
<td>Advanced Landscape Research</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>L. Pellissier, U. Gimmi, M. Hunziker</td>
</tr>
</tbody>
</table>

Abstract
This course introduces landscapes as socially perceived, spatially and temporally dynamic entities that are shaped by natural and societal factors. Concepts and qualitative and quantitative methods to study landscapes from an ecological, societal and historical perspective are presented. In a term paper students work on a landscape-related topic of their choice.

Objective
Students will:
- learn about concepts and methods to quantify structural and functional connectivity in landscapes, particularly
- be introduced to the topic of landscape genetics and its benefits and (current) limitations for applied conservation
- understand the role of landscape for human well-being
- be introduced into approaches of actively influencing attitudes and behavior as well as related scientific evaluation
- make use of various historical sources to study landscapes and their dynamics
- interpret landscapes as a result of ecological constraints and anthropogenic activities.

Content
1. Encompassing concepts and approaches
- European Landscape Convention (ELC)
- Ecosystem Services (ES): introduction and critical evaluation

2. Ecological approach:
- green infrastructure (e.g., ecological conservation areas)
- landscape connectivity
- landscape genetics and management applications
- concepts of specific quantitative methods: least cost paths, resistance surfaces, Circuitscape, networks (Conefor), land-use change models, various statistical methods

3. Social-science approach:
- principle of landscape as perceived and connoted environment
- theories on landscape preference and place identity
- role of landscapes for recreation, health and well-being
- intervention approaches for influencing attitudes and related behavior
- methods of investigating the human-landscape relationship and evaluating interventions

4. Historical approach:
- land use history of Switzerland (agricultural history, forest and woodland history)
- historic legacies of land use in landscapes and ecosystems
- historic-ecological approaches and applications

5. Land change science:
- modelling future land-use (CLUE, other scenario-based models)
- landscape functions and services

Lecture notes
Handouts will be available in the course and for download

Prerequisites / notice
Basic Landscape Ecology courses at Bachelor level

Mountain Forest Hydrology

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<th>Number</th>
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<tbody>
<tr>
<td>701-1644-00L</td>
<td>Mountain Forest Hydrology</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>J. W. Kirchner</td>
</tr>
</tbody>
</table>

Abstract
This course presents a process-based view of the hydrology, biogeochemistry, and geomorphology of mountain streams. Students learn how to integrate process knowledge, data, and models to understand how landscapes regulate the fluxes of water, sediment, nutrients, and pollutants in streams, and to anticipate how streams will respond to changes in land use, atmospheric deposition, and climate.

Objective
Students will have a broad understanding of the hydrological, biogeochemical, and geomorphological functioning of mountain catchments. They will practice using data and models to frame and test hypotheses about connections between streams and landscapes.

Content
Streams are integrated monitors of the health and functioning of their surrounding landscapes. Streams integrate the fluxes of water, solutes, and sediment from their contributing catchment area; thus they reflect the spatially integrated hydrological, ecophysiological, biogeochemical, and geomorphological processes in the surrounding landscape. At a practical level, there is a significant public interest in managing forested upland landscapes to provide a reliable supply of high-quality surface water and to minimize the risk of catastrophic flooding and debris flows, but the scientific background for such management advice is still evolving.

Using a combination of lectures, field exercises, and data analysis, we explore the processes controlling the delivery of water, solutes, and sediment to streams, and how those processes are affected by changes in land cover, land use, and climate. We review the connections between process understanding and predictive modeling in these complex environmental systems. How well can we understand the processes controlling watershed-scale phenomena, and what uncertainties are unavoidable? What are the relative advantages of top-down versus bottom-up approaches? How much can "black box" analyses reveal about what is happening inside the black box? Conversely, can small-scale, micro-mechanistic approaches be successfully "scaled up" to predict whole-watershed behavior? Practical problems to be considered include the effects of land use, atmospheric deposition, and climate on streamflow, water quality, and sediment dynamics, illustrated with data from experimental watersheds in North America, Scandinavia, and Europe.

Lecture notes
Handouts will be available as they are developed.

Literature
Recommended and required reading will be specified at the first class session (with possible modifications as the semester proceeds).

Ecosystem Management

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
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<tr>
<td>701-1631-00L</td>
<td>Foundations of Ecosystem Management</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>J. Ghazoul, A. Giger Dray</td>
</tr>
</tbody>
</table>

Number of participants is limited to 35.

Priority is given to the target groups until 26.09.2022,
This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

At the end of this course participants will be able:

- To describe forest management and silvicultural measures for enhancing forest resilience to climate change, increased disturbances, and invasive species, and evaluate their feasibility and effectiveness in various situations;

- To concisely describe silvicultural options for the management of multifunctional forests and critically evaluate their feasibility and suitability;

- To explain the various social expectations towards forest ecosystem services and their implications for multifunctional forest management and critically analyse conflicts and synergies resulting from different forest ecosystem services;

- To carry out research on a given topic, identify relevant literature and present the results in a structured presentation and discuss the implications for forest management.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

This is a 5 credit course.

Literature


Prerequisites / notice

Course language is English. Prerequisites: Sufficient English language skills.

Lecture notes

No class notes or text books

Lecture presentations are available for download.

Waiting list will be deleted on 30.09.2022
#### Decision Making, Policy and Planning

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1651-00L</td>
<td>Environmental Governance</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>E. Lieberherr</td>
</tr>
</tbody>
</table>

**Priority is given to the target groups until 19.09.2022,**

**Target groups:**
- Environmental Sciences MSc
- Agricultural Sciences MSc

**Waiting list will be deleted on 23.09.2022**

**Abstract**
The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

**Objective**
- To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.
- To analyze the evolution as well as the key elements of environmental governance.
- To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

**Content**
Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

**Key questions that this course seeks to answer:**
- What are the core characteristics of environmental challenges from a policy perspective?
- What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?

**Lecture notes**
Lecture slides, a script and additional course material will be provided on Moodle.

**Prerequisites / notice**
A detailed course schedule will be made available at the beginning of the semester.
During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)

<table>
<thead>
<tr>
<th>Taught competencies</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td>Self-direction and Self-management</td>
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Abstract
Measurements are the sole judge of scientific truth and provide access to unpredictable information, enabling the characterization and monitoring of complex terrestrial systems. Based on lectures and field- and laboratory training, the students learn to apply modern methods to determine forest inventory parameters and to measure subsurface properties and processes.

Objective
The students will be able to:
- explain measurement principles that are used for characterization of landscapes and terrestrial systems
- select appropriate measurement methods and sampling design to quantify key variables and processes above ground and in the subsurface
- deploy sensors in the field
- interpret collected laboratory and field data and report main conclusions deduced from measurements

Content
Week 1: Plant-Soil interactions – short introduction before sensor demonstration and installation in forest lab; Scholander pressure bomb (suction in leaves); LiCOR soil chamber

Week 2: Lecture on Measurement Science, overview of water content and water potential sensors; data logging and data logger programming; tests in the lab

Week 3: Introduction on soil physics; Field installation of sensors and field experiment; data collection for a few days; solar panel

Week 4: Soil sampling in field lab including geoprobe measurements

Week 5: Introduction on forest lab - Soil sampling in forest lab; root length density;

Week 6: Lecture on geophysical methods on Subsurface Characterization: Basic principles of ERT, GPR, and EM; simple lab tests on effective resistivity

Week 7: Demonstration and application of geophysical methods in the field

Week 8: Lecture on plant soil relationship; connecting information below and above ground – data analysis

Weeks 9 and 10: Forest characterization/ inventory: Principles of LiDAR; structures and features of the tree crowns, size/volume of the leaf area tree positions and diameters at breast height

Weeks 11 and 12: Eddy covariance methods -Principles for field measurement of water vapor, carbon dioxide, and energy exchange between terrestrial surfaces and the atmosphere; Analysis of measured time series to determine evaporation rate and CO2-fluxes

Week 13: Swiss Soil Monitoring networks – Monitoring of soil water content and potential; climate change and droughts

Week 14: Global data – Global modeling and data interpretation; SoilGrids and OpenLandMap; exercises on Budyko analysis

Literature
Lecture material will be online for registered students using moodle

Prerequisites / notice
The details of the schedule will be optimized based on the number of students; some blocks of the course will be offered as well to students of Environmental Engineering

701-1679-00L Landscape Modelling of Biodiversity: From Global Changes to Conservation
Does not take place this semester.

Abstract
The course provides the student with the spatial tools to address societal challenges toward ensuring the sustainable use of terrestrial ecosystems and the conservation of biodiversity. Students learn theory, tools and models during a few introductory sessions and apply this knowledge to solve a practical problem in groups related to climate change, land use change and biodiversity conservation.

Objective
Students learn:
- Theoretical foundations of the species ecological niche
- Biodiversity concepts and global change impacts
- Basic concepts of spatial (macro-) ecology
- Environmental impact assessment and planning
- Advanced statistical methods (GLM, GAM, CART) and basic programming (loops, functions, advanced scripting) in the statistical environment R.
- The use of GIS functionality in R

Content
1. The basics:
   Introduction to the concept of the ecological niche, and biodiversity theories. Overview of the knowledge on expected biodiversity response to global changes and conservation planning methods.
   Introduction to the statistical methods of Generalized Linear (GLM) and Generalized Additive models (GAM), and Classification and Regression Trees (CART). Introduction to basic GIS and programming elements in the statistical environment R.

2. The class project:
   Students form groups of two, and each group solves a series of applied questions independently in R using the techniques taught in the introductory classes. The students then prepare a presentation and report of the obtained results that will be discussed during a mini-symposium. Each team chooses one of the following topics for the class project:
   a) Linking climate change velocities to species' migration capacities
   b) Explaining and modelling land use change in Switzerland
   c) Explaining and modelling biodiversity changes in Switzerland
   d) Designing biodiversity conservation strategies under global changes.

Prerequisites / notice
Basic knowledge in statistics (OLS regression, test statistics), and basic knowledge in geographic information science.

Electives
Natural Science Foundations

Number Title Type ECTS Hours Lecturers
701-1620-00L Tree Genetics – Concepts and Applications W 3 credits 2G A. Rudow, P. Brang, F. Gugerli

Abstract
Trees are important elements and drivers of ecosystem processes in forests and landscapes. Tree species diversity and intraspecific genetic diversity are relevant factors for continuous adaptation, required for a sustainable maintenance of forest products and services. Sustainable forest and landscape management under climate change has to take forest genetic resources into consideration.
Objective

The educational goals of the course are:
- To know basic concepts of evolution and molecular and quantitative methods of genetics.
- To understand the most relevant processes of gene flow, adaptation and species interactions, on the basis of ecological theories and case studies on forest tree species.
- To know management principles and instruments for the promotion and the conservation of forest genetic resources, with a view on application in practice.

Content

The course provides a comprehensive overview on concepts and applications of tree genetics and complements basic knowledge of biology, dendrology, forest ecology and forest management in the frame of forest and landscape management topics. It introduces concepts of evolution and genetic methods as foundations, explains the most important processes and drivers of gene flow and adaptation, including coevolutionary aspects of associated organisms, and shows relevant topics of the management of genetic resources from reproduction to conservation and monitoring. Their theories and application into practice are illustrated on behalf of case studies on forest tree species. Two full-day excursions illustrate the contents with exemplary objects, actors and applications in Switzerland.

Lecture notes

Script: modular slide script (parts by each lecturer).

Literature

A. Gessler, M. Lehmann, 2016: Ecosystem Management - Naturschutz und Naturschutzbiologie
- Raum- und Regionalentwicklung
- Systematische Botanik
- Pflanzen- und Vegetationsökologie
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

751-5125-00L Stable Isotope Ecology of Terrestrial Ecosystems

Abstract

This course provides an overview about the applicability of stable isotopes (carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H)) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

Objective

Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small Isotope project, practice to search and analyze literature as well as to give an oral presentation. The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally. This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

Lecture notes

Handouts will be available on the webpage of the course.

Literature

Will be discussed in class.

Prerequisites / notice

This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

Taught competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Problem-solving
  - Project Management
  - Communication
  - Cooperation and Teamwork
  - Creative Thinking
  - Self-direction and Self-management

ECTS

2 credits

Lecturers

R. A. Werner, N. Buchmann, A. Gessler, M. Lehmann

Number of participants limited to 20.

ECTS

3 credits

Lecturers

F. Knaus

Number of participants limited to 20.

ECTS

3 credits

Lecturers

H. Griess, J. Schweier

Number of participants limited to 20.

ECTS

2 credits

Lecturers

H. Griess, J. Schweier

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2210 of 2345
Objective
In this course, students will learn to use a wide variety of approaches grounded in the natural sciences, engineering and technology to develop solutions tailored to unique challenges from the field of forest operations. The course is aimed at students who either plan an academic or professional career in the field of forest operations, or who will work at the interface between forest operations and the various related disciplines, such as forest ecosystem management and forestry in the wider sense. After participating in this course students will have acquired foundational knowledge of a wide variety of core elements in the field of forest operations:
- The course will provide students with the ability to describe and differentiate site and stand conditions from an engineering perspective.
- Students will gain an overview and good working knowledge of current technology used in forest operations in Switzerland and around the world.
- Students will acquire the ability to assess the strength and weaknesses of the most commonly used equipment and analyze their suitability for a given set of environmental, economic and social factors.
- Students will be able to combine different types of technology to create an optimal harvesting system for a given task, and assess a given system for its task specific suitability.
- Participants will be able to assess the sustainability and potential short- and long-term impacts of harvesting systems under ecological, economic and social constraints.

Content

Introduction
- Historic overview
- Scope of operation
- Site and stand characteristics

Timber harvesting
- Logging methods
- Felling methods
- Motor- Manual felling methods
  - Falling and processing
- Forest machine structure and function
- Harvester Technology
  - Felling heads
  - Carriers for felling heads
- Bunching
- Mechanical processing
- Loading equipment
- Operating techniques

Primary Transport Systems
- Ground based
  - Common features
  - Skidder
  - Forwarder
  - Loader Forwarder
- Cable yarding
  - Common features
  - Wire rope
  - Cable yarding systems
  - Operating techniques
- Aerial
  - Common features
  - Operating techniques

Winch-Assisted Harvesting Operations
- Harvesting
- Primary transport

Loading Equipment

Secondary transport
- Truck configurations
- Soil compaction and contamination
- Riparian areas

Forest Operations management
- Ergonomics
- Work Safety
- Economic Aspects
- Environmental impact assessment
- Equipment selection

Forest operations across the globe
- New Zealand
- North America
  - British Columbia, Canada
  - South-eastern U.S.A

Specialized equipment for small scale forest operations

Literature
Published on Moodle

Prerequisites / notice
701-1544-00 Forest Access and Transportation

Decision Making, Policy and Planning

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>103-0468-00L</td>
<td>Participatory Environmental Modeling</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>N. Salliou, B. Black</td>
</tr>
</tbody>
</table>

Abstract
The lecture accompanies students into a participatory modelling process. We explore environmental topics such as urban agriculture or climate-resilient city. Students will get to know participatory modelling tools as well as concepts and approaches related to it. Students elaborate the processes from questions to interactive operational models.
Objective

In this course students will learn:

- The process of developing a model to address an environmental problem: from choosing an appropriate technique (Agent-based modelling, Bayesian Networks, and System dynamics), to conceptualization and model building.
- Communication and facilitation skills to foster effective and legitimate collaboration with stakeholders.

Students then apply this knowledge and skills to a real-life case study, creating a model with stakeholders to address an environmental problem.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Adaptability and Flexibility</td>
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<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
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<td>Media and Digital Technologies</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
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<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
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<td>Negotiation</td>
<td>Self-direction and Self-management</td>
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</table>

Methods and Tools

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1316-00L</td>
<td>Physical Transport Processes in the Natural Environment</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>J. W. Kirchner</td>
</tr>
</tbody>
</table>

Abstract

Fluid flows transport all manner of biologically important gases, nutrients, toxins, contaminants, spores and seeds, as well as a wide range of organisms themselves. This course explores the physics of fluids in the natural environment, with emphasis on the transport, dispersion, and mixing of solutes and entrained particles, and their implications for biological and biogeochemical processes.

Objective

Students will learn key concepts of fluid mechanics and how to apply them to environmental problems. Weekly exercises based on real-world data will develop core skills in analysis, interpretation, and problem-solving.

Content

- Dimensional analysis, similarity, and scaling
- Solute transport in laminar and turbulent flows
- Transport and dispersion in porous media
- Transport of sediment (and adsorbed contaminants) by air and water

Lecture notes

The course is under development. Lecture materials will be distributed as they become available.

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<th>Number</th>
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<tr>
<td>701-1677-00L</td>
<td>Quantitative Vegetation Dynamics: Models from Tree to Globe</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>H. Lischke, U. Hiltner, B. Rohner</td>
</tr>
</tbody>
</table>

Abstract

The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

Objective

Students will learn key concepts of fluid mechanics and how to apply them to environmental problems. Weekly exercises based on real-world data will develop core skills in analysis, interpretation, and problem-solving.

Content

- Deriving single-plant models from inventory measurements
- Plant models based on ‘first principles’

Models at the stand scale
- Simple approaches: matrix models
- Competition for light and other resources as central mechanisms
- Individual-based stand models: distance-dependent and distance-independent
- Theoretical models

Models at the landscape scale
- Simple approaches: cellular automata
- Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
- Landscape models

Global models
- Sacrificing local detail to attain global coverage: processes and entities
- Dynamic Global Vegetation Models (DGVMs)
- DGVMs as components of Earth System Models

Lecture notes

Handouts will be available in the course and for download

Literature

Will be indicated at the beginning of the course

Prerequisites / notice

- Ideally basic experiences in modelling and systems analysis
- Basic knowledge of programming, ideally in R
- Good knowledge of general ecology, ideally of vegetation dynamics and forest systems

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2212 of 2345
The students learn the basics of geographic data processing based on the programming language Python and ArcGIS (arcpy). They get hands-on experience based on the demonstration of wood (increment cores, stem discs, wedges), sampling in the field, and measuring and dating of tree rings in the tree-ring lab.

- solve R-based exercises (R tutorial will be provided) and answer questions in Moodle;
- work out an independent research question related to a dendroecological topic and write a short literature review based on scientific papers.

The course dendroecology offers theoretical and practical aspects of dendrochronology. The impact of different environmental influences (climate, site, competition, insects, fire, physical-mechanical influences) on trees and tree rings.

Objective
- understand, how wood is configured and how tree-ring structures are formed.
- are able to identify and describe different tree-ring structures.
- understand the theoretical and practical aspects of the dating of tree rings.
- know the effects of different abiotic and biotic environmental influences (climate, site, competition, insects, fire, physical-mechanical influences) on trees and tree rings.
- discover a tool for understanding and reconstructing global change processes.
- learn software to date, standardize and analyze tree rings.
- get hands-on experience based on the demonstration of wood (increment cores, stem discs, wedges), sampling in the field, and measuring and dating of tree rings in the tree-ring lab.
- solve R-based exercises (R tutorial will be provided) and answer questions in Moodle;
- work out an independent research question related to a dendroecological topic and write a short literature review based on scientific papers.

Abstract

The course communicates the basics of the programming language Python and gives a general introduction into the geoprocessing frameworks arcpy and covers basic language concepts of Python such as datatypes, control structures and functions. In addition the application of popular Python libraries in combination with libraries in their Python scripts and know how the libraries are applied to spatial datasets.

The students are able to implement their own processing sequences and models for geoprocessing. The students are able to integrate open source framework of ArcGIS. In addition various Python libraries (numpy, Scipy, GDAL, statsmodels, pandas, Jupyter Notebook) will be introduced.

Objective
- Overview and history of dendrochronology
- Principles of dendrochronology
- Formation and structure of wood and tree rings
- Wood anatomy and intra-seasonal tree-ring growth
- Continuous and discontinuous tree-ring characteristics
- Sampling and measuring of tree rings
- Crossdating methods (visual, skeleton plots, quantitative)
- Detrending and standardization of tree-ring series
- Development of tree-ring chronologies
- Water transport in trees
- Stable isotopes in tree rings
- Climate influences, climate-growth relationships, climate reconstructions
- Reconstruction of forest dynamics (regeneration, growth, competition, mortality)
- Disturbance ecology (fire, insects, blowdown)
- Application of tree-ring research in practice and in interdisciplinary research projects
- Field and lab day (date for one entire day or two half days will be searched together with the students in the beginning of the semester): discussion of different dendroecological questions in the forest; sampling of trees; insight into different tree-ring projects in the lab (Swiss Federal Institute for Forest, Snow and Landscape Research WSL).

Waiting list will be deleted 13.09.2022.
Number of participants limited to 30.

- Number of participants is limited to 80.
- Priority is given to the target groups until 23.09.2022,
- Course registration starts on 31.08.2022.
- Number of participants is limited to 30.
- Requirements: Basics of biology, ecology and forest ecology
The students are able to

- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content

- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice

252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umweltwissenschaften

Environmental Systems Data Science: Machine Learning

Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022.

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning models to their scientific work.

Objective

The students are able to

- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variables
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content

- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature
Building on existing data science resources

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

401-0627-00L Smoothing and Nonparametric Regression with Examples

Abstract

Starting with an overview of selected results from parametric inference, kernel smoothing will be introduced along with some asymptotic theory, optimal bandwidth selection, data driven algorithms and some special topics. Selected numerical examples will be used for motivation. The presented methods will also be applicable elsewhere.

Objective

The students will learn about methods of kernel smoothing and application of concepts to data. The aim will be to build sufficient interest in the topic and intuition as well as the ability to implement the methods to various different datasets.

Content

- Parametric estimation methods: selection of important results
  - Method of Least squares: regression & diagnostics
  - Nonparametric curve estimation
  - Density estimation, Kernel regression, Local polynomials, Bandwidth selection, various theoretical results related to consistency
  - Selection of special topics (as time permits, we will discuss some of the following): rapid change points, mode estimation, partial linear models, probability and quantile curve estimation, etc.
- Applications: potential areas of applications will be discussed such as, change assessment, trend and surface estimation and others.

Lecture notes

Brief summaries or outlines of some of the lecture material will be communicated to registered students by Email. Additional comments may appear at https://www.wsl.ch/en/employees/ghosh.html.

NOTE: These notes will tend to be just sketches whereas only the in-class lessons will contain complete information.
## Colloquium

<table>
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<th>Hours</th>
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<tbody>
<tr>
<td>701-1691-00L</td>
<td>Colloquium Forest and Landscape Management</td>
<td>Z</td>
<td>0</td>
<td>1.5K</td>
<td>H. Bugmann</td>
</tr>
</tbody>
</table>

**Abstract:**
This course is geared towards outreach and dissemination of research results to Swiss forest practitioners.

**Objective:**
Exchange platform between forest science and forest practitioners, geared towards Swiss stakeholders

**Lecture notes:**
N/A

**Literature:**

Additional references will be given out in the lectures.

### Major in Human Health, Nutrition and Environment

#### Public Health

The module Public Health is compulsory for all students in the major Human Health, Nutrition and Environment.

<table>
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<th>Number</th>
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</thead>
<tbody>
<tr>
<td>401-0629-00L</td>
<td>Applied Biostatistics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Tanadini</td>
</tr>
</tbody>
</table>

**Abstract:**
This course covers the main methods used in Biostatistics. It starts by revising Linear Models (Regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

**Objective:**
After this course students:
- revised Linear Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

**Content:**
This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

**Prerequisites / notice:**
The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommend to view the online R course "etutoR".

#### Epidemiology and Prevention

<table>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
</tr>
</tbody>
</table>

**Abstract:**
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

**Objective:**
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

**Content:**
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

**Taught competencies:**
- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management
- Method-specific Competencies
- Social Competencies
- Personal Competencies
  - Creative Thinking
  - Critical Thinking

**Prerequisites / notice:**
Got introduced to Linear Mixed-Effects Models
- revised or got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

#### Public Health Concepts

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-6151-00L</td>
<td>Public Health Concepts</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Heusser</td>
</tr>
</tbody>
</table>

**Abstract:**
The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

**Objective:**
At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

**Content:**
Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).

**Lecture notes:**
Handouts are provided to students in the classroom.
### Nutrition and Health

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, C. Hartmann</td>
</tr>
<tr>
<td>752-5103-00L</td>
<td>Functional Microorganisms in Foods</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>C. Lacroix, A. Geinaert, A. Greppi</td>
</tr>
</tbody>
</table>

**Abstract**
- This course focuses on food consumer behavior, consumer’s decision-making processes and consumer’s attitudes towards food products.
- The course provides an overview of the following topics: Factors influencing consumer’s food choice, food and health, attitudes towards new foods and food technologies, labeling and food policy issues.

**Objective**
- To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

**Content**
- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

**Lecture notes**
- Copy of the power point slides from lectures will be provided.

**Literature**
- A list of topics for group projects will be supplied, with key references for each topic.

**Prerequisites / notice**
- This lecture requires strong basics in microbiology.

### Environment and Health

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. B. Zimmermann</td>
</tr>
</tbody>
</table>

**Abstract**
- To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Objective**
- To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease as well as the progression of complications of the chronic diseases.

**Content**
- The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Lecture notes**
- There is no script. Powerpoint presentations will be made available on-line to students.

**Literature**
- To be provided by the individual lecturers, at their discretion.

**Prerequisites / notice**
- No compulsory prerequisites, but prior completion of the courses “Introduction to Nutritional Science” and “Advanced Topics in Nutritional Science” is strongly advised.

### Infectious Diseases

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
</tbody>
</table>

**Abstract**
- Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year according to the progress and new results occurring in the field.

**Objective**
- This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

**Content**
- A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

**Lecture notes**
- Papers and class notes can be downloaded from a web page announced during the lecture.

**Literature**
- Papers will be assigned and downloaded from a web page announced during the lecture.

### Data: 18.08.2022 12:39 Autumn Semester 2022 Page 2216 of 2345
Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

Practical exercises:
1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (≤ 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:

- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Objectives
- Development of T and B cells
- The dynamics of an immune response during acute and chronic infections
- Mechanisms of immunopathology
- Modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Content
development of T and B cells
- The dynamics of an immune response during acute and chronic infections
- Modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Prerequisites / notice
Immunology I and II recommended but not compulsory

Abstract
This course provides a detailed understanding of - development of T and B cells - the dynamics of an immune response during acute and chronic infection - mechanisms of immunopathology - modern vaccination strategies

Objective
Obtain a detailed understanding of - the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses, - Recognition of pathogenic microorganisms by the host cells and molecular events thereafter, - events and signals for maturation of naïve B cells to antibody producing plasma cells and memory B cells, - Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the “Danger” concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notif=1&ting=1

Prerequisites / notice
Immunology I and II recommended but not compulsory

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture.

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

Semester Paper and Seminar
The compulsory course 701-1701-00L Human Health, Nutrition and Environment: Term Paper is offered in the autumn semester only.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---

Abstract
Writing of a review paper of scientific quality on a topic in the domain of Human Health, Nutrition and Environment based on critical evaluation of scientific literature.

Objective
- Acquisition of knowledge in the field of the review paper
- Assessment of original literature as well as synthesis and analysis of the findings
- Practising of academic writing in English
- Giving an oral presentation with discussion on the topic of the review paper

Content
Topics are offered in the domains of the major ‘Human Health, Nutrition and Environment’ covering ‘Public Health’, ‘Infectious Diseases’, ‘Nutrition and Health’ and ‘Environment and Health’.

Lecture notes
Guidelines will be handed out in the beginning.

Literature
Literature will be identified based on the topic chosen.

Electives
Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
701-3001-00L | Environmental Systems Data Science: Data Processing | W | 2 credits | 2G | L. Pellissier, E. J. Harris, J. Payne, M. Volpi

**Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.**

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

701-3003-00L | Environmental Systems Data Science: Machine Learning | W | 3 credits | 2G | L. Pellissier, E. J. Harris, J. Payne, M. Volpi

Number of participants is limited to 80.

Course registration starts on 31.08.2022,
Priority is given to the target groups until 23.09.2022,
Target groups
Agricultural Sciences MSc
Abstract
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning models.

Objective
The students are able to:
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature
- Building on existing data science resources

Prerequisites / notice
- Math IV, VI (Statistics); R, Python; ESDS I

Minors
Minor in Sustainable Energy Use

Number Title Type ECTS Hours Lecturers
701-0967-00L Project Development in Renewable Energies W 2 credits 2G R. Rechsteiner, A. Appenzeller

Abstract
Realization of projects in the field of renewable energies, analysis of legal frame conditions and risks. The students learn basics of renewable energy project realization from acknowledged experts active in the field. They identify different tasks of various investor types. They develop sample projects in practice within groups.

Objective
You will receive a practice-oriented introduction to the regulatory, legal and business requirements for renewable energy projects. The possibilities of integrating fluctuating energy production in an environment of volatile prices will be demonstrated. Exercises based on concrete project examples in groups.

Content
- Business models for renewable energy projects
- Introduction of market trends, market structure, technical trends and regulation in Switzerland and in the EU internal energy market
- Necessary frame conditions for profitable projects
- Project development samples and exercises in wind power, hydro power, photovoltaics
due diligence and country assessment.

Exact Program in German below
http://www.rechsteiner-basel.ch/index.php?id=27

Lecture notes
PPT presentation will be distributed (in German)

Literature
- Mit einer grünen Anlage schwarze Zahlen schreiben Link
- UNEP: Global Trends in Renewable Energy Investments
- Wind Technologies Market Report, Lawrence Berkeley National Laboratory
https://emp.lbl.gov/wind-technologies-market-report
- IEA PVP'S: TRENDS IN PHOTOVOLTAIC APPLICATIONS
http://www.iea-pvps.org
- Bundesamt für Energie: Perspektiven für die Grosswasserkraft in der Schweiz
http://www.news.admin.ch/NSSSubscriber/message/attachments/33285.pdf
- Verbrauchsabhängiges Abrechnungsmodell Energie und Wasser, VEWA-Modell Bund

Unterlagen Kleinwasserkraft-Projekte
https://www.bfe.admin.ch/bfe/de/home/versorgung/erneuerbare-energien/wasserkraft/kleinwasserkraft.html

Unterlagen Windkraft-Projekte
https://www.bfe.admin.ch/bfe/de/home/versorgung/erneuerbare-energien/windenergie.html

Verbrauchsabhängiges Abrechnungsmodell Energie und Wasser, YEVA-Modell Bund

Leitfaden zur Beglaubigung von Anlagedaten der Pronovo
https://pronovo.ch/download/leitfaden-zur-beglaubigung-von-anlage-und-produktionsdaten/?wpdmdl=7339

Leitfaden Eigenverbrauch ZEV
https://pubdb.bfe.admin.ch/de/publication/download/9329
### Prerequisites / notice
For group exercise and presentation reasons the number of participants is limited at 30 students. For exercises students build learning and presentational groups. Credit points are based on group performance.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Group</th>
<th>Instructors</th>
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</thead>
<tbody>
<tr>
<td>701-1346-00L</td>
<td>Carbon Mitigation</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>N. Gruber</td>
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<td>Priority is given to the target groups: Bachelor and Master Environmental Sciences and PhD Environmental Sciences until 20.09.2022. Waiting list will be deleted 30.09.2022.</td>
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<td>Number of participants limited to 100</td>
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<td>Abstract</td>
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<td>Future climate change can only kept within reasonable bounds when CO₂ emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.</td>
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<td>The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.</td>
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<td>Content</td>
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<td>From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.</td>
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<td>Lecture notes</td>
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<td>None</td>
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<td>Literature</td>
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<td>Will be identified based on the chosen topic.</td>
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<td>Prerequisites / notice</td>
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<td>Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.</td>
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<tr>
<td>052-0609-00L</td>
<td>Energy and Climate Design I</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>A. Schlüter</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.</td>
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<td>At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (<a href="https://moodle-app2.let.ethz.ch/course/view.php?id=11917">https://moodle-app2.let.ethz.ch/course/view.php?id=11917</a>). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.</td>
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<td>Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:</td>
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<td>1. Local potentials</td>
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<td>2. Demand estimation</td>
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<td>3. Supply concepts</td>
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<td>Lecture notes</td>
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<td></td>
<td>Material on moodle serves as lecture notes.</td>
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<tr>
<td></td>
<td>Literature</td>
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<td>A list of relevant literature is available at the chair and through moodle.</td>
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<td>Taught competencies</td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>227-0731-00L</td>
<td>Power Market I - Portfolio and Risk Management</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>D. Reichelt, G. A. Koeppel</td>
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<td></td>
<td>Abstract</td>
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<td>Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.</td>
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Content
1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX
2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions
3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
2.8. Risk Management 3 (enterprise wide)
4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

Lecture notes
Handouts of the lecture
Prerequisites / notice 1 excursion per semester, 2 case studies, guest speakers for specific topics.
Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

Minor in Physical Glaciology

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>101-0289-00L</td>
<td>Applied Glaciology</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>D. Farinotti, A. Bauder, M. Werder</td>
</tr>
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</table>

Abstract
The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

Objective
The objectives of the courses are to:
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

Content
The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Lecture notes
Digital lecture handouts will be distributed prior to each class.

Literature
Links to relevant literature will be provided during the classes.

Prerequisites / notice
Completed BSc studies. Basic knowledge in computer scripting in any language (e.g., Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management not assessed
Social Competencies
Communication not assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed
Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management assessed

651-1581-00L Seminar in Glaciology
W 3 credits 2S A. Bauder, M. Jacquemart
Abstract
Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.

Objective
In-depth knowledge of selected topics in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

Content
Selected topics of scientific research in Glaciology

Lecture notes
Copies/pdf of scientific papers will be distributed during the course (moodle interface)

Prerequisites / notice
Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

Taught competencies
Subject-specific Competencies Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving not assessed
Project Management not assessed

Social Competencies Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management not assessed

651-4077-00L Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)

W 3 credits 1V University lecturers

Abstract
Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

Objective
Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

Content
Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).

Lecture notes
Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

Prerequisites / notice
Basic knowledge about geomorphology and glaciers/merafrost from corresponding courses at ETH/UZH or from the related lecture notes

651-4101-00L Physics of Glaciers

W 3 credits 3G M. Lüthi, F. T. Walter, M. Werder

Abstract
Erosion and sedimentation by glaciers as a function of topography, englacial temperature, sediment balance, sliding and melt water runoff.

Objective
Knowledge of the most prominent climate-related georomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.

Content
Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).

Lecture notes
Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

Prerequisites / notice
Basic knowledge about geomorphology and glaciers/merafrost from corresponding courses at ETH/UZH or from the related lecture notes

Minor in Catchment Management and Natural Hazards

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<th>Number</th>
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<tr>
<td>701-0565-00L</td>
<td>Principles of Natural Hazard Management</td>
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<td>3</td>
<td>4G</td>
<td>V. Griess, A. Mathys</td>
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</table>

This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.
Objective

By the end of the course, students will be able to:

- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.
- develop, formulate and present solutions to these challenges to a critical audience.

Literature will be distributed and available on Moodle

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<tr>
<td>101-1250-00L</td>
<td>Management of Hillslope and Channel Processes</td>
<td>3</td>
<td>W</td>
<td>D. Rickenmann</td>
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<td>To recognise and understand channel and hillslope processes and their interactions. To learn about methods of hazard analysis and of technical and bioengineering protection measures and their assessment. Determination of critical loads and design of protective structures. Assessment of spatial and future developments with and without protective measures.</td>
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<tr>
<td>102-0293-00L</td>
<td>Hydrology</td>
<td>3</td>
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<td>P. Burlando</td>
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<td>The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.</td>
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<td>Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.</td>
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Content

The hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

Precipitation: mechanisms of precipitation formation, precipitation measurements, variability of precipitation in space and time, precipitation regimes, point/basin precipitation, isohyetal method, Thiessen polygons, storm rainfall, design hyetograph.

Interception: measurement and estimation.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton’s equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnian surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – baseflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rationale, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Snow (and ice) hydrology: snow characteristic variables and measurements, estimation of snowmelt processes by the energy budget equation and conceptual melt models (temperature index method and degree-day method), snowmelt runoff.

Lecture notes

The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.

Lecture notes

Written course documentation available under “Kursunterlagen”.

Literature


Prerequisites and notice

Knowledge of statistics is a prerequisite. The required theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:

- Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters).
- Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

651-3525-00L

Introduction to Engineering Geology

Abstract

This introductory course starts from a description of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

Objective

Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

Content


Lecture notes

Written course documentation available under “Kursunterlagen”.

Literature


651-4088-03L

Physical Geography III (Geomorphology and Glaciology) (University of Zürich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO231

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmss/en/studies/application/deadline s.html

Abstract

Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufes. Dabei werden einzelne Wasserspeicher (Schnee-, Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

Minor in Forest Engineering and Wood Products

To successfully complete this minor, KPs must be earned for the two required courses:

- 701-1645-00 Forest Operations (autumn semester) and
- 701-1544-00 Forest Access and Transportation (spring semester)
Abstract
The discipline of Forest operations is constantly challenged to find solutions for unique problems. Each forest site requires specific technological approaches and machinery based on given management goals and ecological and environmental circumstances. Various terrain types and soil conditions, harvesting costs and taking care of the workforce by creating safe working conditions are some of the aspects that need to be considered. The course is aimed at students who either plan an academic or professional career in the field of forest operations, or who will work at the interface between forest operations and the various related disciplines, such as forest ecosystem management and forestry in the wider sense.

Objective
In this course, students will learn to use a wide variety of approaches grounded in the natural sciences, engineering and technology to develop solutions tailored to unique challenges from the field of forest operations. The course will provide students with the ability to describe and differentiate site and stand conditions from an engineering perspective. Students will gain an overview and good working knowledge of current technology used in forest operations in Switzerland and around the world. Students will acquire the ability to assess the strength and weaknesses of the most commonly used equipment and analyze their suitability for a given set of environmental, economic and social factors. Students will be able to combine different types of technology to create an optimal harvesting system for a given task, and assess a given system for its task specific suitability. Participants will be able to assess the sustainability and potential short- and long-term impacts of harvesting systems under ecological, economic and social constraints.

Content
Introduction
• Historic overview
• Scope of operation
• Site and stand characteristics

Timber harvesting
• Logging methods
• Felling methods
• Motor-Manual felling methods
  o Falling and processing
• Forest machine structure and function
• Harvester Technology
  o Felling heads
  o Carriers for felling heads
• Bunching
• Mechanical processing
• Loading equipment
• Operating techniques

Primary Transport Systems
• Ground based
  o Common features
  o Skidder
  o Forwarder
  o Loader Forwarder
• Cable yarding
  o Common features
  o Wire rope
  o Cable yarding systems
  o Operating techniques
• Aerial
  o Common features
  o Operating techniques

Winch-Assisted Harvesting Operations
• Harvesting
• Primary transport

Loading Equipment

Secondary transport
• Truck configurations
• Soil compaction and contamination
• Riparian areas

Forest Operations management
• Ergonomics
• Work Safety
• Economic Aspects
• Environmental impact assessment
• Equipment selection

Forest operations across the globe
• New Zealand
• North America
  o British Columbia, Canada
  o South-eastern U.S.A

Specialized equipment for small scale forest operations

Outlook into the future of forest operations
Published on Moodle

Literature

Prerequisites / notice
701-1544-00 Forest Access and Transportation

Number of participants limited to 15.
Abstract
The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general and species-specific relationships between growth processes, wood properties and wood function in the living tree.

Objective
Learning target is a basic understanding of the anatomy of wood and the related impact of endogenous and exogenous factors. The students will learn how to distinguish common Central European wood species at the macroscopic and microscopic level. A deeper insight will be given by wood identification exercises for softwood species. Further, the students will gain insight into the relationships between tree growth and wood properties with a specific focus on the wood function in the living tree.

Content
In an introduction to wood anatomy, the general structural features of softwoods and hardwoods will be explained and factors of diversity and variability will be discussed. A specific focus is laid on common Central European tree species with relevance in the wood sector, which will be studied in macro- and microstructural investigations. In the following, relationships between wood structure, properties and function in the tree will be the focus of the lectures. Topics covered are wood transport, trends in wood anatomy, wood defects and their causes, tools to study wood properties over time, secondary changes in wood, and tree biomechanics.

101-0637-20L Fundamentals of Wood Elaboration and Woodmachining

Abstract
The course Wood processing conveys knowledge on technological properties of wood and wood-based materials as well as on industrial processes for the fabrication of a vast variety of wood products and covers new developments in the field of digital technologies.

Objective
Learning target is a fundamental understanding of the dominating wood machining processes, which are applied to fabricate common wood products. Students will be introduced to the economic relevance of the renewable resource wood and are trained in its technological properties. The students will learn to identify the relationships between wood species and their properties as well as the suitable machining processes to fabricate targeted wood products. Finally, the digital transformation process, which will affect all sectors of the wood industry with impact on the entire value chain and business models will be covered. It will be illustrated how production processes will become more flexible, efficient and less resource demanding.

Content
The general introduction shows the economic relevance of the resource wood in a global, European and Swiss context and reflects aspects of sustainability in wood production and certification. In terms of bulk wood products a specific focus is laid on sawn timber production and drying processes. With regard to wood veneer production, steaming, veneer cutting and assembly to veneer lumber products are presented. Further the common technologies for the production of particle boards and fibre boards as well as paper will be discussed. In the following, the topics are related to wood gluing and wood protection as well as potentials and limitations in the application of wood and wood-based products. In a further part, the lecture deals with the most important digital technologies, e.g. Internet of Things, artificial intelligence and their impact on the wood industry on the basis of illustrative examples. At the end of the lecture an excursion to a Swiss wood manufacturer is planned, in order to facilitate practical experience.

Minor in Agricultural Plant Production and Environment

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1343-00L</td>
<td>Soil-Plant Water Relations</td>
<td>W</td>
<td>3</td>
<td></td>
<td>A. Carminati</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 40.</td>
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<tr>
<td></td>
<td>Priority is given to the target groups: Master Environmental Sciences, Master Agricultural Sciences and Master Environmental Engineering until 29.08.2022.</td>
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<tr>
<td></td>
<td>Waiting list will be deleted 02.10.2022.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Water limitation is a primary constraint on plant growth and terrestrial fluxes worldwide. In this course, the principles of water flow in soil and plants are discussed, with particular attention on the effect of drought on root water uptake, transpiration and plant growth. Strategies of plants to tolerate drought are discussed.</td>
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<tr>
<td>Objective</td>
<td>The students are able to: explain and compare systematically the drivers of water stress to plants; to solve the equations of water flow in soil and plants and to calculate plant water status for varying pedoclimatic conditions and plant traits; to critically review and present one research question in soil-plant water relations; to openly debate on the current trends in soil and plant water research.</td>
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<tr>
<td>Content</td>
<td>24:09: Introduction.</td>
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</tr>
<tr>
<td>01.10</td>
<td>Soil water relations; Principles of soil water retention and soil water flow; Soil hydraulic properties.</td>
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</tr>
<tr>
<td>08.10</td>
<td>Root water uptake; soil hydraulic constraints on transpiration</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>15.10</td>
<td>Rhizosphere processes and properties; root-soil contact; root hairs; mycorrhiza; rhizodeposition.</td>
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<tr>
<td>22.10</td>
<td>Water flow in roots and xylem; root anatomy, architecture and plasticity; cavitation.</td>
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<td></td>
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</tr>
<tr>
<td>28.10</td>
<td>Transpiration; Vapor Pressure Deficit; Photosynthesis; Stomatal regulation</td>
<td></td>
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</tr>
<tr>
<td>05.11</td>
<td>Soil-plant-atmospheric continuum; Below- and above-ground feedbacks; Soil and atmospheric drivers of transpiration losses.</td>
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<tr>
<td>12.11</td>
<td>Modelling Soil-Plant Water Relations (Concept)</td>
<td></td>
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<tr>
<td>19.11</td>
<td>Modelling Soil-Plant Water Relations (Implementation)</td>
<td></td>
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<tr>
<td>26.11</td>
<td>Plant response to drought and consequences for agriculture and forests. Open questions and introduction to seminar topics.</td>
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<tr>
<td>03.12</td>
<td>Group work in the class</td>
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<tr>
<td>10.12</td>
<td>Seminar (presentation of papers)</td>
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<tr>
<td>17.12</td>
<td>Seminar (presentation of papers)</td>
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</tr>
<tr>
<td>24.12</td>
<td>Seminar (presentation of papers)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Lecture notes; selection of articles</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Vadose Zone Hydrology/Environmental Soil Physics (recommended but not required)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>751-3700-00L</th>
<th>Plant Ecophysiology</th>
<th>W</th>
<th>2</th>
<th>2</th>
<th>N. Buchmann, A. Walter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO2 concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO2 gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data is included.</td>
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<tr>
<td>Objective</td>
<td>The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant physiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Handouts stehen online.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>This course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems.</td>
<td></td>
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</tr>
</tbody>
</table>
Lecturers

(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research. Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

Objective

Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.

Content

Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

Lecture notes

none

Prerequisites / notice

Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Method-specific Competencies

Analytical Competencies assessed

Social Competencies

Communication assessed

Personal Competencies

Critical Thinking assessed

Self-direction and Self-management assessed

ECTS

2

751-4104-00L

Alternative Crops

W

2 credits

2V

A. Walter, K. Berger Büter

Abstract

Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

Objective

During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

751-4704-00L

Weed Science

W

3 credits

2G

B. Streit, U. J. Haas

Abstract

Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.

Objective

At the end of the course the students are qualified to develop sustainable solutions for weed problems in agricultural and natural habitats.

Content

Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.

751-5003-00L

Sustainable Agroecosystems II

W

2 credits

2V

K. Benabderrazik, J. Six

Abstract

This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Objective

(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content

The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) in both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management). The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholders in the food system in order to support a sustainable transformation.

Literature


Prerequisites / notice

Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed

Method-specific Competencies

Analytical Competencies assessed

Social Competencies

Cooperation and Teamwork assessed

Personal Competencies

Critical Thinking assessed

Self-awareness and Self-reflection assessed

Self-direction and Self-management assessed

ECTS

2

Minor in Environmental, Resource and Food Economics

Number

Title

Type

ECTS

Hours

Lecturers

363-0537-00L

Resource and Environmental Economics

W

3

2G

L. Bretschger

Data: 18.08.2022 12:39
Autumn Semester 2022
Page 2227 of 2345
Abstract

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare economics and how to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare economics and how to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Objective

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Literature


Prerequisites / notice

knowledge of basic concepts of probability theory and microeconomics

751-0903-00L Microeconomics of the Agriculture and Food Sector

Abstract

In dieser Vorlesung werden ökonomische Charakteristika des Agrar- und Lebensmittelsektors herausgearbeitet und anderen Sektoren gegenübergestellt. Fokus ist dabei Lebensmittelindustrie in der Schweiz und in der EU. Es werden mikroökonomische Zusammenhänge, insbesondere zur Preis- und Mengenbildung in verschiedenen Wettbewerbsmodellen, am Fallbeispiel des Agrar- und Ernährungssektors vermittelt.

Objective


Content

- Der Agrar- und Lebensmittelsektor in der EU und der Schweiz
- Preiselastizitäten von Angebot und Nachfrage im Ernährungssektor
- Gewinnmaximierung
- Grundlagen der Spieltheorie
- Monopol / Monopolistischer Wettbewerb
- Oligopol (Stackelberg, Cournot, Bertrand)
- Monopson
- Produktdifferenzierung
- Preisdiskriminierung
- Kartelle

Literature


Prerequisites / notice

Empfohlene Vorkenntnisse:
- Grundkenntnisse der Ökonomie/Agrarökonomie
- Vorlesung Einführung in die Mikroökonomie

Taught competencies

Subject-specific Competencies

- Concepts and Theories

Method-specific Competencies

- Decision-making

Social Competencies

- Negotiation

Personal Competencies

- Critical Thinking

751-1311-00L Introduction to Agricultural Management

Abstract

Vermittlung von betriebswirtschaftlichen Grundlagenwissen und Analyse- und Planungsinstrumenten mit Anwendung auf Unternehmen der Agrar- und Ernährungswirtschaft
<table>
<thead>
<tr>
<th>Objective</th>
<th>Students should be able to describe the dynamics of hierarchies, markets and cooperation in an agricultural context.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>The main part of this lecture will examine constellations where hierarchies, markets or cooperation have been observed and described in the agricultural sector. On a more aggregated level, different agricultural systems will be evaluated in terms of main socioeconomic parameters like social capital or perceptions.</td>
</tr>
<tr>
<td>Literature</td>
<td>see script</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Basic economic knowledge is expected.</td>
</tr>
</tbody>
</table>

### 751-2105-00L Political Ecology of Food and Agriculture

<table>
<thead>
<tr>
<th>Objective</th>
<th>We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.</td>
</tr>
</tbody>
</table>
The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) They know the basics of how to design and implement a policy evaluation study. 3) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.), They make hands-on experiences of methodological challenges. 4) They can critically assess the science-policy interface of policy evaluations.

751-2903-00L Evaluation of Agricultural Policies

<table>
<thead>
<tr>
<th>Taught competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Leadership and Responsibility</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Taught</td>
<td>Decision-making</td>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
<td>Creative Thinking</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>Negotiation</td>
<td></td>
<td>Critical Thinking</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td></td>
<td>Self-awareness and Self-reflection</td>
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<td></td>
<td></td>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0019-00L</td>
<td>Readings in Environmental Thinking</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>J. Ghazoul</td>
</tr>
</tbody>
</table>

This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance, and shaped its relevance to society. Above all, the course seeks to give confidence and raise enthusiasm among students to read more widely around the broad subject of environmental sciences and management both during the course and beyond.

The course will provide students with opportunities to read, discuss, evaluate and interpret key texts that have shaped the environmental movement and, more specifically, the environmental sciences. Students will gain familiarity with the foundational texts, but also understand the historical context within which their academic and future professional work is based. More directly, the course will encourage debate and discussion of each text that is studied, from both the original context as well as the modern context. In so doing students will be forced to consider and justify the current societal relevance of their work.

The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion.

Waiting list will be deleted 30.09.2022.

Number of participants limited to 20.

Thereafter, in each week a text (typically a chapter from a book or a paper) considered to be seminal or foundational will be assigned by a course lecturer. The lecturer will introduce the selected text with a brief background of the historical and cultural context in which it was written, with some additional biographical information about the author. He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session.

Presentation of the text requires the students to prepare by, for example:

- identifying the key points made within the text
- identifying issues of particular personal interest and resonance
- considering the impact of the text at the time of publication, and its importance now
- evaluating the text from the perspective of our current societal and environmental position

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

The specific texts selected for discussion will vary, but examples include:

- Leopold (1949) A Sand County Almanach
- Carson (1962) Silent Spring
- Jared Diamond (2005) Collapse

Discussions might also encompass films or other forms of media and communication about nature.
The students are able to

Target groups
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
- The students are able to
  - frame a data science problem and build a hypothesis
  - describe the steps of a typical data science project workflow
  - conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
  - critically think about the limits and implications of a method
  - visualise data and results throughout the workflow
  - access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
- 252-0840-02L  Anwendungssnahes Programmieren mit Python
- 401-0624-00L  Mathematik IV: Statistik
- 401-6215-00L  Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L  Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L  Mathematik VI: Angewandte Statistik für Umweltwissenschaften

Course Catalogue of ETH Zurich

Professional Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1001-00L</td>
<td>Professional Internship</td>
<td>O</td>
<td>30 credits</td>
<td>to be announced</td>
<td></td>
</tr>
</tbody>
</table>

Only for Environmental Sciences MSc.

Completion and enrollment for the course "Professional Internship" is only possible after admission requirements and all additional requirements are fulfilled.

Registration and recognition of professional internship via
https://www.lehrbetrieb.ethz.ch/praxis
No registration in myStudies required. For more information: www.usys.ethz.ch/internship-envsc

Abstract
In the compulsory internship outside of ETH Zürich, the students in Environmental Sciences learn about how environmental issues are handled professionally through their own practical work and by applying the knowledge they acquired. They will analyse complex environmental problems on scientific, technical and social levels and develop solutions in conjunction with social actors.

Objective
During the internship, students will learn how to professionally handle environmental issues from the technical-scientific, planning, administrative, and/or advisory perspective through their own practical experiences. They should apply the knowledge acquired from their studies. Furthermore, students will deepen their understanding in terms of development and implementation of environmental-friendly solutions in an everyday work-routine. Through this experience, they will develop important professional competence. Moreover, the internship will show them possible professional fields and establish valuable contacts for starting their careers in the future.

Content
The professional internship is a compulsory part of the Master’s degree programme and requires that each student complete 18 weeks outside of ETH Zurich. It can be completed in Switzerland or abroad. The students choose the position of the internship themselves. The position needs to fulfil the aims and requirements of the compulsory internship.

Job positions for environmental scientists are available in the following areas: environmental consulting firms, engineering and planning offices, clean-tech companies, industrial and service companies, federal administration, administration of cantons and municipalities, organisations and associations as well as companies operating in education, higher education, and media in relation to environmental and sustainable themes. Generally, the internship is performed outside the realm of the university.

Further support is provided by the company catalogue with companies in Switzerland and abroad that offer internships according to job positions for environmental scientists are available in the following areas: environmental consulting firms, engineering and planning offices, clean-tech companies, industrial and service companies, federal administration, administration of cantons and municipalities, organisations and associations as well as companies operating in education, higher education, and media in relation to environmental and sustainable themes. Generally, the internship is performed outside the realm of the university.

Lecture notes
Detailed instructions and templates on the compulsory internship can be found online on Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15228

Further information and support online https://moodle-app2.let.ethz.ch/course/view.php?id=15228
Master's Thesis

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1002-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

- Only students who fulfill the following criteria are allowed to begin with their Master's thesis:
  a) The signed request for the Bachelor's Degree Certificate has been submitted or processed.
  b) At least 32 CP of coursework related to the major have been acquired.
  c) All additional requirements (as stated in the admissions decision), including any assessment repetitions, are fulfilled.

Additional information is posted on the following webpage: https://www.usys.ethz.ch/en/studies/environmental-sciences/master/thesis.html

Objective

The study programme is completed by a Master's thesis. The Master's thesis is an independent, scientific work. A topic within the field of specialization is chosen. It lasts 6 months.

Course Units for Additional Admission Requirements

The courses below are only available for Master students with additional admission requirements.

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

Students understand basic microeconomics and macroeconomics problems and theories. They are able to argue along economic principles and to judge policy measures.

Objective

- Upon successful completion of the course, you will be able to:
  - Describe the basic microeconomic and macroeconomic problems and theories.
  - Make economic arguments to a given topic.
  - Evaluate economic measures.

Content

- Households, firms, supply and demand: How are household preferences and consumption behavior formed? How does a household react to price changes? How are goods prices formed? At what prices are firms willing to offer goods? How do we make economic decisions?
- Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can governments influence the market?
- Market failure: What happens when prices give wrong signals?
- Labor market: How do supply and demand work in the labor market? What influences unemployment?
- National Accounts: How big is the Swiss economy?
- Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?
- Money and inflation: What exactly is money? How does money creation work, and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society.

Literature


<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>406-0062-AAL</td>
<td>Physics I</td>
<td>E-</td>
<td>5 credits</td>
<td>11R</td>
<td>A. Vaterlaus</td>
</tr>
</tbody>
</table>

Abstract

Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter. The student should acquire an overview over the basic concepts in mechanics.
Mathematics I

Concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter. The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content


Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature

see "Content"

Literature

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002, 544 S, ca.: Fr. 68.-

406-0063-AAL

Physics II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content


Chapters:

and: 15 (without 15-3, 15-5, 15-7, 15-9, 15-10, 15-11)

Literature

see "Content"

Literature

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003, Fr. 77.-

406-0064-AAL

Physics I and II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract


Objective

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter. The student should acquire an overview over the basic concepts used in mechanics, in the theory of heat and electricity.

Content


Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6), 15 (without 15-3, 15-5, 15-7, 15-9, 15-10, 15-11), 17 (without 17-5, 17-10), 18 (without 18-5, 18-6, 18-7), 19, 20 (without 20-7, 20-8, 20-9, 20-10, 20-11), 21 (without 21-12), 23, 25 (without 25-9, 25-10), 26 (without 26-4, 26-5, 26-7), 27, 28 (without 28-4, 28-5, 28-9, 28-10), 29 (without 29-5, 29-8), 32 (without 32-8), 33 (without 33-4, 33-5, 33-9, 33-10), 34 (without 34-4, 34-6, 34-7), 35 (without 35-2, 35-3, 35-9, 35-11, 35-12, 35-13).

and: 15 (without 15-3, 15-5, 15-7, 15-9, 15-10, 15-11)

Literature

see "Content"

Literature

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Verlag Wiley-VCH, 2002, 544 S, ca.: Fr. 68.-

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003, Fr. 77.-

406-0251-AAL

Mathematics I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Objective

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.
### Mathematics I

Mathematics I covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems, notably through:

- Multivariable Differential Calculus:
  - functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.

- Multivariable Integral Calculus:
  - multiple integrals, line and surface integrals, work and flux, Green, Gauss and Stokes theorems, applications.

### Mathematics II

Mathematics II is a continuation of the topics of Mathematics I, with main focus on multivariable calculus.

### Content

1. **Linear Algebra and Complex Numbers:**
   - systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

2. **Single-Variable Calculus:**
   - review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

3. **Ordinary Differential Equations:**
   - separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

### Prerequisites / notice

- Familiarity with the basic notions from Calculus, in particular those of function, derivative and integral.

### Literature

- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

### Prerequisites

- Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

### Assistance

- Tuesdays and Wednesdays 17-18h, in Room HG E 41.
Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student’s t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

529-2001-AAL Chemistry I and II E- 9 credits 19R J. Cvengros
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature
Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

Taught competencies
Subject-specific Competencies Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed
Social Competencies Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed
Personal Competencies Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management assessed

529-0234-AAL Chemistry I E- 4 credits 11R J. Cvengros

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 2235 of 2345
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
Chemistry I: Chemical bonding and molecular structure, chemical thermodynamics and kinetics, chemical equilibrium.

**Objective**
Acquiring the basics for describing the structure, composition and transformations of the material world. Introduction to thermodynamically determined chemical-physical processes. Use modeling to show how macroscopic phenomena can be understood in terms of atomic and molecular properties. Applications of theory to qualitatively and quantitatively solve simple chemical and environmental problems.

**Content**
1. stoichiometry
2. atomic structure
4. basics of chemical thermodynamics
   - System and environment. Description of the state and changes of state of chemical systems.
5. first law
   - Internal energy, heat and work. Enthalpy and enthalpy of reaction. Standard thermodynamic conditions.
6. second law
   - Entropy. Entropy changes in the system and in the universe. Reaction entropy due to heat of reaction and due to changes in matter.
7. Gibbs energy and chemical potential.
   - Combination of the two main theorems. Reaction Gibbs energy.
8. chemical equilibrium
   - Mass activities in gases, condensed substances and dissolved species. Gibbs energy in the course of chemical reactions. Equilibrium constant.
9. acids and bases
10. dissolution and precipitation
    - Heterogeneous equilibria. Dissolution process and solubility constant. Speciation diagrams. The carbon dioxide-carbonate equilibrium in the environment.

**Literature**
529-2002-AAL

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Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**
Chemistry II: Redox reactions, chemistry of the elements, introduction to organic chemistry

**Objective**
Erweitern der allgemeinen Grundlagen und Erarbeiten einer Basis, um Prozesse in komplexeren Umweltystemen (Wasser / Luft / Boden) in ihrem zeitlichen und quantitativen Ablauf verstehen und beurteilen zu können.

**Content**
1. Redoxreactions
2. Inorganic Chemistry
   - Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.
3. Introduction to organic chemistry
   - Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups. Stereochemistry.
   - Rection mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds). Chemistry of carbony and carboxyl groups.
   - Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.

**Literature**
Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Intercultural Competences: not assessed
- Negotiation: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

General Biology I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

Objective
The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Content
Week 1–7 by Alex Widmer, Chapters 12–25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogenetic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8–14 by Oliver Martin, Chapters 26–34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular & seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

Lecture notes
No script

Literature

Prerequisites / notice
This is a virtual self-study lecture for non-german speakers of the "Allgemeine Biology I (551-0001-00L) lecture. The exam will be written jointly with the participants of this lecture.

Example exam questions will be discussed during the lectures, and old exam questions are kept by the various student organisations. If necessary, please contact Prof. Uwe Sauer (sauer@ethz.ch) for details regarding the exam.

General Biology II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Biology I: Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

Objective
General Biology I: The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Objective
General Biology II: Molecular biology approach to teach the basic principles of biochemistry, cell biology, cgenetics, evolutionary biology and form and function of vascular plants.
General Biology I focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Specifically the following Campbell chapters will be covered:

- 3 Biochemistry Chemistry of water
- 4 Biochemistry Carbon: the basis of molecular diversity
- 5 Biochemistry Biological macromolecules and lipids
- 7 Cell biology Cell structure and function
- 8 Cell biology Cell membranes
- 10 Cell biology Respiration: introduction to metabolism
- 11 Cell biology Photosynthetic processes
- 16 Genetics Nucleic acids and inheritance
- 17 Genetics Expression of genes
- 18 Genetics Control of gene expression
- 19 Genetics DNA Technology
- 35 Plant structure & function Plant Structure and Growth
- 36 Plant structure & function Transport in vascular plants
- 37 Plant structure & function Plant nutrition
- 38 Plant structure & function Reproduction of flowering plants
- 39 Plant structure & function Plants signal and behavior

This is a virtual self-study lecture for non-German speakers of the "Allgemeine Biology I (551-0001-00L)" and "Allgemeine Biology II (551-0002-00L)" lectures. The exam will be written jointly with the participants of this lecture.

701-0023-AAL Atmosphere E- 3 credits 6R E. Fischer, T. Peter

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Objective
Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Content
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Lecture notes
Written information will be supplied.

Literature

701-0071-AAL Mathematics III: Systems Analysis E- 4 credits 9R R. Knutti, H. Wernli

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.
Readings from a text book will focus on understanding central processes in community ecology. Topics will include demographic and biological processes. Selected mathematical topics are presented for later use in more specialised lectures. Part of the topics were already discussed in the lectures Mathematics I-III. Here, they should be shortly recapitulated and most importantly applied to practical problems. If necessary, new mathematical concepts and methods will be introduced in order to solve challenging and inspiring problems from practice.

### Mathematics V: Applied Deepening of Mathematics I - III

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

This course assigns reading for students needing further background for understanding ecological processes. Central problems in ecology, including population growth and regulation, the dynamics of species interactions, the influence of spatial structure, the controls over species invasions, and community responses to environmental change will be explored from basic and applied perspectives.

**Objective**

Original language Students will understand how ecological processes operate in natural communities. They will appreciate how the mathematical background, the mathematical concepts and much of all with their application and interpretation.

**Content**

Practical examples from the following areas will be discussed: ordinary differential equations; eigenvalue problems from linear algebra; systems of linear and nonlinear differential equations; partial differential equations (diffusion, transport, waves).

### Biology III: Essentials of Ecology

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

This course assigns reading for students needing further background for understanding ecological processes. Central problems in ecology, including population growth and regulation, the dynamics of species interactions, the influence of spatial structure, the controls over species invasions, and community responses to environmental change will be explored from basic and applied perspectives.

**Objective**

Original language Students will understand how ecological processes operate in natural communities. They will appreciate how the mathematical background, the mathematical concepts and much of all with their application and interpretation.

**Content**

Upon completing the course, students will be able to:

- Understand the factors determining the outcome of species interactions in communities, and how this information informs management.
- Apply theoretical knowledge on species interactions to predict the potential outcomes of novel species introductions.
- Understand the role of spatial structure in mediating population dynamics and persistence, species interactions, and patterns of species diversity.
- Use population and community models to predict the stability of interactions between predators and prey and between different competitors.
- Understand the conceptual basis of predictions concerning how ecological communities will respond to climate change.

**Lecture notes**

In addition to the self-learning literature handouts are distributed.

### Hydrosphere

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

In this self-study course, students learn about relevant processes that control the water cycle on earth. Energy and mass exchange, mixing and transport processes are described and the coupling of the hydrosphere with the atmosphere and the solid Earth are discussed.

**Objective**

Qualitative and quantitative understanding on how physical (and geochemical) processes control the natural dynamics in groundwater, lakes ans oceans and constrain the exchange of mass and energy.

**Content**

Topics of the course.
- Physical properties of water (i.e. density and equation of state)
- global water resources
- Exchange at boundaries
- energy (thermal & kinetic), gas exchange
- Mixing and transport processes in open waters
- vertical stratification, large scale transport
- turbulence and mixing
- mixing and exchange processes in rivers
- Groundwater and its dynamics
- ground water as part of the terrestrial water cycle
- ground water hydraulics, Darcy's law
- aquifers and their properties
- hydrochemistry and tracer
- ground water use
- Case studies
  - 1. Water as resource, 2. Water and climate

**Lecture notes**

In addition to the self-learning literature handouts are distributed.
Literature

Textbooks for self-studying.
Surface water.
Chapter 19.2: Bottleneck Boundaries

Ground water:

Optional additional readers.


701-0473-AAL Weather Systems E- 3 credits 6R M. A. Sprenger, F. Scholder-Aemisegger
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The students learn about the dynamical features of the Earth's atmosphere. They interpret satellite imagery and learn about basic concepts in dynamical meteorology. The global circulation is briefly discussed, before introducing the Eulerian and the Lagrangian perspective, which are used to study air streams in extratropical cyclones and to investigate basic aspects in mountain meteorology.

Objective
The students are able to:
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of the role of moist adiabatic processes for weather systems and why stable water isotopes are useful in this context

Content
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situtations; Eulerian and Lagrangian perspective; potential vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer

Lecture notes Lecture notes and slides

Literature
Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

701-0475-AAL Atmospheric Physics E- 3 credits 6R F. Mahrt
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, thermodynamics, aerosol physics, radiation as well as the impact of aerosols and clouds on climate and artificial weather modification.

Objective
Students are able to:
- to explain the mechanisms of cloud and precipitation formation using knowledge of humidity processes and thermodynamics
- to evaluate the significance of clouds and aerosol particles for climate and artificial weather modification.

Content
Moist processes/thermodynamics; aerosol physics; cloud formation; precipitation processes, storms; importance of aerosols and clouds for climate and weather modification, clouds and precipitation

Lecture notes
Powerpoint slides and script will be made available

Literature

701-0501-AAL Pedosphere E- 3 credits 6R R. Kretzschmar
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties.

Objective
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

Content
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, physical soil properties and functions, chemical soil properties and functions, soil formation, principles of soil classification, global soil regions, soil fertility, land use and soil degradation.

Literature

Prerequisites / notice
Prerequisites: Basic knowledge in chemistry, biology and geology.

Taught competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

701-0721-AAL Psychology E- 3 credits 6R M. Siegrist
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course unit is an introduction to the field of psychology. It covers the basic concepts and theories of psychology, as well as an introduction to research methods in psychology.

Objective
The students are able to:
- to understand the historical development of psychology and the main theoretical approaches
- to appreciate the diversity of psychological perspectives and methodologies
- to critically assess psychological research and its implications for society

Content
Basic concepts and theories of psychology, research methods, biopsychology, cognitive psychology, social psychology, clinical psychology, and developmental psychology.

Lecture notes
Lecture notes and slides

Literature
The course readings will be assigned during the first class meeting and will be available through the lecture website.

3 credits
4 credits
5 credits
6 credits
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This self-study course is an introductory course in psychology. This course will emphasize cognitive psychology and the psychological experiment.

Objective
Knowledge of key concepts and exemplary theories of psychology and their relation to "daily" psychology. Comprehension of relation between theory and experiment in psychology.

Goals: Learning how psychologists are thinking, a side change from the ETH natural science perspective to psychological thinking.

Domains of psychology:
- Psychology fields
- Concept definitions of psychology
- Theories of psychology
- Methods of psychology
- Results of psychology

Capability:
Be able to define a psychological research question
Basics understanding of role of psychology

Comprehension:
Psychology as a science of experience and behavior of the human

Content
Einführung in die psychologische Forschung und Modellbildung unter besonderer Berücksichtigung der kognitiven Psychologie und des psychologischen Experiments. Themen sind u.a.: Wahrnehmung; Lernen und Entwicklung; Denken und Problemlösen; Kognitive Sozialpsychologie; Risiko und Entscheidung.

Literature
English book of Zimbardo (http://www.amazon.de/Psychology-Life-Discovering-Psych-Lab/dp/0205654770/ref=sr_1_2?s=books-intl-de&ie=UTF8&qid=1317208260&sr=1-2)

Prerequisites / notice
Determine with Prof. Dr. Michael Siegrist the chapters in "Zimbardo" which are compulsory reading
Read the two Psychology chapters (6 + 7) from the book of Prof. Roland W. Scholz

752-4001-AAL Microbiology E- 2 credits 4R M. Ackermann
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Self-study course in microbiology.

Objective
Teaching of basic knowledge in microbiology.

Content
This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature
This self-study course is based on the book ‘Brock, Biology of Microorganisms’.
The course gives an overview on the following topics: hydrostatics, capillarity, hydrodynamic instabilities, fragmentation. Tension in liquids,

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics

Class notes and handouts

• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
• High Performance Computing for Science and Engineering (HPCSE) I

3G

S. M. Martin, J. H. Walther

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance engineering (HPC) architectures.

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/

Class notes, handouts

• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
• Lecture notes

Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

Hydrodynamics and Cavitation

W 4 credits

3G

O. Supponen

The course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

The main learning objectives of this course are:
1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify hydrodynamic instabilities and discuss the stability region
3. Describe fragmentation of liquids
4. Explain tension, nucleation and phase-change in liquids.
5. Describe hydrodynamic cavitation and its consequences in physical terms.
6. Recognise experimental techniques and industrial and medical applications for cavitation.

The course gives an overview on the following topics: hydrostatics, capillarity, hydrodynamic instabilities, fragmentation, Tension in liquids, phase change. Cavitation: single bubbles (nucleation, dynamics, collapse), cavitating flows (attached, cloud, vortex cavitation). Industrial applications and measurement techniques.

Literature

• Fluid dynamics I & II or equivalent

Renewable Energy Technologies

W 4 credits

3G

A. Steinfeld, E. I. M. Casati

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture Notes containing copies of the presented slides.

Prerequisites / notice

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

Fluid Dynamics with the Lattice Boltzmann Method

W 4 credits

3G

I. Karlin

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
Content

The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   - Particle’s distribution function, Liouville equation, entropy, ensembles; Kinetic theory; Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   - Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   - Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   - Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to lattice Boltzmann methods:
   - Relativistic fluid dynamics; flows with phase transitions.

Lecture notes

Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice

The course addresses mainly graduate students (MSc/PhD) but BSc students can also attend.

151-0293-00L

Combustion and Reactive Processes in Energy and Materials Technology

Abstract

The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials.

Objective

The students should become familiar with the fundamentals and with application examples of chemically reactive processes in energy conversion (combustion engines in particular) as well as the synthesis of new materials. The lecture is part of the focus “Energy, Flows & Processes” on the Bachelor level and is recommended as a basis for a future Master in the area of energy. It is also a facultative lecture on Master level in Energy Science and Technology and Process Engineering.

Content


Lecture notes

No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English

Literature


151-0509-00L

Acoustics in Fluid Media: From Robotics to Additive Manufacturing

Abstract

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

Lecture notes


Literature

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.
After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. This course aims to familiarize motivated M/BSc students with some of the basic phenomena of particles at the nanoscale, thereby illustrating the links between physics, chemistry, and nanotechnology. It provides an overview of the field with motivating lectures from industry and academia, including the development of technologies and processes based on particle technology with introduction to design methods of mechanical processes, scale-up laws and optimal use of materials and energy. Most importantly, this course aims to develop the creativity and sharpen the communication skills of motivated students through their individual projects, a PERFECT preparation for the M/BSc thesis, or effective oral/written project presentations, the future profession itself, and even life, in general. To provide guidance throughout the course, lectures include some of the following:

- Overview & Project Presentation
- Particle Size Distribution
- Particle Diffusion
- Agglomeration & Coalescence
- Particle Growth by Condensation
- Control of particle size & structure during gas-phase synthesis
- Multi-scale design of aerosol synthesis of particles
- Particle Characterization
- Aerosol manufacture of nanoparticles
- Forces acting on Single Particles in a Flow Field
- Fixed and Fluidized Beds
- Separations of Solid-Liquid & Solid-Gas systems
- Emulsions/droplet formation/microfluidics
- Gas Sensors
- Coaching for proposal & report writing as well as oral presentations

**Literature**

FluidMechanik I, Thermodynamik I & II & "clean" 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As exceptional effort will be required! Having seen "Chasing Mavericks" (2012) by Apted & Henson, "Unbroken" (2014) by Angelina Jolie and, in particular, "The Salt of the Earth" (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).

**151-0905-00L Medical Technology Innovation - From Concept to Clinics**

- Project-oriented learning on how to develop technological solutions to address unmet clinical needs.
- After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This course aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary teamwork and effective communication play a key role.

- Literature will be available on the moodle.
### Taught competencies

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tr>
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<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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#### 151-0913-00L Introduction to Photonics

**W 4 credits 2V+2U R. Quidant, J. Ortega Arroyo**

**Abstract**

This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

**Objective**

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
Content

I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts
Literature
Optics (Hecht) - Pearson
Prerequisites / notice
Physics I, Physics II

151-0917-00L  Mass Transfer  W  4 credits  2V+2U  S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature
Prerequisites / notice
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0927-00L  Rate-Controlled Separations in Fine Chemistry  W  6 credits  3V+1U  M. Mazzotti, V. Becattini, J. Shih

Abstract
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.

Objective
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

Content
The class covers separation techniques that are central in the purification and downstream processing of chemicals and biological pharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

Lecture notes
Handouts during the class
Recommendations for textbooks will be covered in the class. Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00).

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Technical Competencies**
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Social Competencies**
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

**References**

**Prerequisites / notice**
- A 1-day excursion including a visit of a chemical plant will be part of the lecture.

**529-0513-01L Process Simulation and Flowsheeting**
- Abstract: This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies.
- Objective: This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and optimization. Specifically, students will develop the following skills:
  - Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
  - Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
  - Mathematical reasoning and computational skills: the familiarity with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
  - Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.
- Literature:
  - Own scripts
Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimization & debugging

Literature
An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice
A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

Multidisciplinary Courses
The students are free to choose individually from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-1008-00L</td>
<td>Semester Project Process Engineering</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

The subject of the Master Thesis and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

Abstract
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program.

Industrial Internship

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-1090-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>8 credits</td>
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<td>external organisers</td>
</tr>
</tbody>
</table>

Access to the company list and request for recognition under www.mavt.ethz.ch/praxis.

No registration required via myStudies.

Abstract
The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Objective
The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</table>

Autumn Semester 2022
Students who fulfill the following criteria are allowed to begin with their Master's Thesis:

a. successful completion of the bachelor program;

b. fulfilling of any additional requirements necessary to gain admission to the master programme;

c. successful completion of the semester project and industrial internship;

d. achievement of 28 ECTS in the category "Core Courses".

The Master's Thesis must be approved in advance by the tutor and is supervised by a professor of ETH Zurich.

### Seminars, Colloquia, and Additional Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>151-0931-00L</td>
<td>Seminar on Particle Technology</td>
<td>E-</td>
<td>0</td>
<td>3S</td>
<td>S. E. Pratsinis</td>
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<tr>
<td>227-0920-00L</td>
<td>Seminar in Systems and Control</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>F. Dörfier, R. D'Andrea, E. Frazzoli, M. H. Khammash, J. Lygeros, R. Smith</td>
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<tr>
<td>227-0970-00L</td>
<td>Research Topics in Biomedical Engineering</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>K. P. Prüßmann, S. Kozerke, M. Stampanoni, K. Stephan, J. Vörös</td>
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</table>

### Process Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>W+</th>
<th>W</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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### Key for Hours

| V  | G   | U   | S  | K   | P | A     | D     | R
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<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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### ECTS

Click for the European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Science in Perspective

In "Science in Perspective"-courses students learn to reflect on ETH’s STEM subjects from the perspective of humanities, political and social sciences.

Only the courses listed below will be recognized as "Science in Perspective" courses.

▶ Type A: Enhancement of Reflection Competence

SiP courses are recommended for bachelor students after their first-year examination and for all master- or doctoral students. All SiP courses are listed in Type A.

Courses listed under Type B are only recommendations for enrollment for specific departments.

▶▶ History

<table>
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<tr>
<th>Number</th>
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<tr>
<td>853-0725-00L</td>
<td>History Part One: Europe (The Cradle of Modernity,</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>H. Fischer-Tiné</td>
</tr>
<tr>
<td></td>
<td>Britain, 1879-1914)</td>
<td></td>
<td>credits</td>
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<tr>
<td>Abstract</td>
<td>A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series asks whether one single model of modernization prevailed on the 'Old Continent' or whether we need to differentiate regionally. A special focus lies on the Swiss experience.</td>
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<tr>
<td>Objective</td>
<td>At the end of this lecture course, students: (a) highlight the most important changes in the &quot;long nineteenth century&quot; in Europe (b) explain their long-term effects; and (c) relate these changes to global developments today.</td>
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<td>Content</td>
<td>The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.</td>
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<td>Literature</td>
<td>Power Point Slides and references will be made available in digital form during the course of the semester.</td>
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<tr>
<td>Prerequisites /notice</td>
<td>Mandatory and further reading will be listed on the course plan that is made available as from the first session.</td>
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</table>

| 851-0105-00L   | Background Knowledge Arabic World                  | W    | 2    | 2V    | U. Gösken     |
|                | This lecture will discuss important topics of the Arab culture involving concepts relating to history, the role of literature, sciences and religion, concepts of 'the West', meaning of education, understanding of culture as well as current concepts and discourses relevant at the sociocultural level. |
| Abstract       | Teaching about epistemic contents relating to the Arabic world that constitute modern Arabs' self-understanding and are relevant for adequate behavior in practically dealing with the Arabic world. What basic knowledge about 'their' culture are Arabs taught? What educational goals are pursued? What is the relationship they build with the West? |
| Objective      | The topics that are discussed on the basis of a scientifically critical approach are concepts and understandings of history, the role of literature, sciences and religion, concepts of the West and the relationship with the West, the role of education, understanding of culture and cultural refinement, current concepts and discourses relevant at the sociocultural level. |
| Literature     | Power Point Slides and references will be made available in digital form during the course of the semester. |
| Prerequisites /notice | Mandatory and further reading will be listed on the course plan that is made available as from the first session. |

| 052-0801-00L   | Global History of Urban Design I                   | W    | 2    | 2G    | T. Avermaete  |
|                | This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances. |
| Abstract       | The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work. |
| Objective      | In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts: |
| Content        | 01: The History and Theory of the City as Project |
|                | 02: Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus |
|                | 03: The Idea of the Polis: Rome, Greece and Beyond |
|                | 04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi |
|                | 05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles |
|                | 06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization |
| Literature     | The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism. |
| Prerequisites /notice | There are three books that will function as main reference literature throughout the course: |
|                | These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans. |

| 851-0157-28L   | Life and Death                                      | W    | 3    | 2V    | M. Hagner     |
|                | Particularly suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS |
| Abstract       | This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century. |
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0426-00L

Paul Feyerabend's Anarchistic Theory of Knowledge

Paul K. Feyerabend characterized his magnum opus “Against method” as an ‘anarchistic theory of knowledge’. In this book, he crusaded against analytical philosophy and scientific rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Content
We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783519289197) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

851-0011-00L

The Body in Global History

While being the universal constant which is common to every human being in history, the body is also culturally and historically specific. In this seminar we will examine how ideas of the body have changed throughout history and how these ideas of the body can be useful to understand political, social, and cultural phenomena in particular historical settings.

Objective
Students learn the history of the body from mid-eighteenth century onwards through examples taken from the multidisciplinary scholarship on the body with a special, albeit not exclusive, focus on colonial and postcolonial contexts. More specifically, students are sensitized to the historical and cultural variations of the human body that challenge scientific understandings of it as an unchanging biological entity. Adopting a humanities perspective on topics like anatomy and surgery, the treatment of the insane, sexuality, physical culture, eugenics, and body productivity, the course looks at shifting attitudes to body health and fitness and the ways these have been shaped by considerations of gender, race, and class as well as by socioeconomic circumstances of modernity. It considers how bodies have historically concerned governments who have classified different (sections of) populations as ‘fit’ or ‘unfit’ to be members of a certain community.

Content
The ‘long durée’ approach of the course allows to consider the continuities and changes in terms of scientific epistemologies and practices regarding the body. In doing so, debated contemporary issues such as assisted reproductive technologies and wearable systems of surveillance of the worker fatigue in the workplace are discussed.

The course is structured thematically, adopts a multidisciplinary approach, and uses academic texts as well as concrete examples. It intends to a) enable STEM students to develop new perspectives on their core subjects by bringing them in dialogue with the themes dealt with and, by raising ethical questions; b) familiarise students in general with major topics in the field of the recent scholarship on the body and make them mindful of the multiple ways in which understanding the body and its relationship with culture and power can help think critically of the present we live in.

851-0040-00L

Can It Be Permissible to Kill a Few in Order to Save Many?

While the relevant literature on moral justifications in trolley cases will be discussed (Foot, Thomson, Kamm, Otsuka, Kagan), second, neuropsychological research on trolley cases (Greene, Haidt, Berker, Kamm) and third, applications of such moral reasoning in cases potentially arising in autonomous robots (Rahwan, Nyholm and Smids, Wolkenstein) will be considered.

Objective
Students will gain an overview of the current ethical debates surrounding the legitimacy of homicide-rescue-cases in specific types of situations. They will be enabled to interpret complex texts, identify the argumentation, to reflect it critically and to put it up for discussion.

Content
Killing innocents is generally thought to be morally impermissible – or so it seems from an intuitive point of view. However, there are situations where people can only be saved if less others are killed, for example, in some traffic cases, in some cases in natural disasters, medical emergencies, terrorist attacks or humanitarian interventions. In some of these situations our intuitions stay clear and disaproving: it is not permissible to kill, even in order to save many lives, for example, to take the vital organs of one patient in order to save many more other patients. In other scenarios, the intuitions are less clear or even revert for most of us, like in the famous trolley-bystander case, in which a bystander can divert an out-of-control trolley heading towards five to a track where one person is trapped. How are these moral intuitions to be justified, if they are? In this seminar the relevant literature on moral justifications in such trolley cases will be reviewed as well as on methodological problems pertaining to the role of intuitions in moral justifications. Neuropsychological research on such cases as well as critique of the methods and normative presuppositions used in that research will be debated. Finally, attempts to apply such moral reasoning on allegedly analogous cases arising in autonomous robots will be discussed.

851-0184-00L

Pluralist Philosophy of Mathematics

This course will follow Michele Friend's book "pluralism in mathematics". It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.

Objective
The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.

Content
The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of a pluralist and paraconsistent philosophical approaches.

851-0101-77L

Science and the State

This course will reflect on historical and contemporary relations between science and the state. Through various case studies, we will inquire how these two institutions shaped each other. The case studies will cover various scientific disciplines.

Objective
To understand how science helped form the state apparatus, and how politics helped shape science; evaluate the image of science as free thinking vs. servant of the state; analyze the role of science in generating political authority and political reasoning; analyze how political ideals are expressed in science.

851-0101-90L

Aesthetics: On the History and Theory of Beauty

This course will follow Michele Friend's book “pluralism in mathematics”. It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.

Objective
The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.

Content
The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of a pluralist and paraconsistent philosophical approaches.

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2251 of 2345
Abstract
The meaning of the "beautiful" seems hard to pin down. Yet intersubjective and objective criteria of the beautiful nevertheless exist. The foundation of aesthetics as a "science" of the beautiful based on sensorious experience temporarily suspended this tension. Since modernity, the question of the beautiful has been ever more open. We shall approach this question theoretically and historically.

Objective
The meaning of the "beautiful" seems hard to define. At first glance, it rather constitutes a merely subjective sensation. Yet, on the other hand, intersubjective, collective and cultural ideas, or even objective criteria of the beautiful exist. Since antiquity, this irresolvable tension has characterized the discourse on the beautiful in the realms of art and philosophy. With the foundation of "aesthetics" in the 18th century, however, this debate was significantly altered. This new "science" aimed at a scientific investigation of the beautiful by situating sensorious impression above logic. While art had hitherto understood as a learnable technique, it now appears as a sensorious and therefore subjectively-realized. The rejection of this optimism marks the turn to modernity that defined itself through a notion of art transcending the beautiful. Ever since, the question as to the meaning of the beautiful has been continuously open for debate. In the course of this seminar, we shall approach this question from a historical as well as theoretical perspective.

851-0435-00L Science and Neoliberalism: From the Critique of Planning to Competition and Think Tanks (1930–2000) W 3 credits 2S M. Wuß

Abstract
From its beginning, the history of neoliberal thought has been linked to debates about the status of knowledge in society. In the seminar, students learn to understand fundamental debates in the theory of science in their political and economic contexts; moreover, we explore to what extent neoliberal thinkers act as "thinkers of the future" and develop specific forms of science policy and science-based research.

Objective
The seminar promotes an understanding of seminal texts in the early philosophy of science (M. Polanyi, J.D. Bernal, etc.) in the context of ideological struggles in the 1930s and 1940s and of the debates about knowledge, science, and society at that time. Moreover, it provides insights into the political and economic foundations of funding policies for education, science, and research that were developed since the 1970s.

Content
Neoliberalism is considered one of the most influential economic currents since the last decades of the 20th century. However, neoliberalism not only has a much longer history, going back to the ideological struggles of the 1930s. Since then, it has also been closely linked to debates about the status of knowledge and science in society. Theorists of science, such as Michael Polanyi, were part of neoliberal discussion circles; economists, such as Friedrich Hayek, developed decentered forms of knowledge as part of market processes. Processes of deinstitutionalization and privatization, the also development of core research areas, are needed for economic growth. Competition and the market were subsequently regarded as the most important driving forces for scientific and economic innovation.

Literature


Abstract
The lecture offers a survey of the historical trajectories taken by the countries of the Indian subcontinent from the 17th century to the turn of the 21st century. The thematic foci include, but are not limited, to an examination of the question whether or not there was a pre-European South Asian modernity.

Objective
Through this course students are acquainted with the history of one of the most important world regions. The objective is not only to introduce participants to a richly diverse civilization, they also encourage to look at interrelations and make comparisons with other regions. The West through this approach their knowledge of European history is contextualised in a global framework while simultaneously their intercultural sensitivity is being trained.

851-0436-00L Popularizing Science. Nonfiction Books Between Academy and Public W 3 credits 2S I. Barner

Abstract
Science needs to be popularized in order to have an impact on society. Conversely, what is thought, read, and communicated outside the universities has an effect on research. The seminar deals with the history of popular knowledge focusing on the non-fiction book.

Objective
The seminar focuses on the reading and discussion of original and secondary texts on the history of the relationship between knowledge, the book market and the public. Students learn to critically engage with sources as well as research literature from the fields of literary, scientific, and book and media history.

Content
The amount of reading will be limited; what is important above all is the seminar discussion. Cooperation with actors in the literary business (authors, agents, editors, publishers) is planned. The students shall learn to prepare interviews and to write short texts in the form of non-fiction.

851-0177-00L Images of Computing W 3 credits 2G J. L. Gastaldi, O. Del Fabbro

Abstract
This seminar will explore different areas of our social and scientific life where computational practices have a critical impact. The goal is to provide a pluralistic conception of computing based on the idea of different worlds dealing with topics as diverse as climate, law, art, or war. The lectures are delivered by researchers from ETH and abroad, with different disciplinary backgrounds.

Objective
By the end of the course, students will be able to describe and compare different conceptions and practices of computing from multiple disciplinary perspectives. They will be able to evaluate both the differences and the convergences between those conceptions, and critically assess their relation to current trends in science, technology, and society.

Content
Computing has become omnipresent in all dimensions of scientific and social life. Not only have cultural phenomena increasingly become the object of computational analysis, but computational practices have also proved inseparable from the cultural environment in which they evolve. Therefore, it is urgent to critically address the entanglement of computing practices with the main cultural challenges our epoch is facing. The global and collective nature of such problems requires a comprehensive perspective on computing, where social and cultural aspects occupy a central position. For these reasons, thinking about computing through a social and cultural approach, where art is as necessary as engineering, anthropological insights as important as psychological models, and the critical perspectives of history and philosophy as decisive as the axioms and theorems of theoretical computer science. In this new edition of the Turing Centre’s ‘Images...’ lecture series, we will explore different areas of our current social and scientific life where computational practices have a critical impact in order to reflect on the multiple impact of computing resulting from them. Instead of asking what computing is in general, the seminar intends to focus on what computing looks like when dealing, for instance, with a climate model, a text of law, a model of a weapon, an artistic creation or a weapon of war. The goal is to achieve a pluralistic conception of computing where its scientific, technical, and cultural aspects remain indissociable. The lectures will be delivered by researchers from ETH and abroad with different disciplinary backgrounds. As part of the Turing Centre, this seminar intends to sow the seed of a suitable and long-term environment for exchanging ideas between multiple fields in the natural sciences and the humanities.
Abstract  
Technology and society cannot be separated: No society functions without technology. The seminar offers a problem-oriented introduction to basic questions of the history of technology, introduces approaches to the history of technology and discusses selected, ongoing debates.

Objective  
The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.

Content  
History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

Prerequisites / notice  
Beginn 2. Semesterwoche (27.9.2022)

<table>
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<td>851-0516-05L</td>
<td>Mobility and the Border: Migration and Control between Mexico and the USA, 19th– 21st Century</td>
<td>3</td>
<td>WS</td>
<td>S. M. Scheuzger</td>
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<tr>
<td>851-0534-00L</td>
<td>Yemeni Civil War: The Arab Spring, State Formation and Regional Rivalry</td>
<td>3</td>
<td>VS</td>
<td>E. Manea</td>
</tr>
<tr>
<td>851-0345-00L</td>
<td>A Seminar Cycle on Africa</td>
<td>3</td>
<td>VS</td>
<td>A. Mabanckou</td>
</tr>
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Abstract  
The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

Objective  
A) The students know relevant approaches of the studies of migration, they are able to assess the analytical capacities of these approaches and they know how to apply them to concrete events and processes.
B) The students have acquired knowledge about important aspects of the history of migration between Mexico and the United States.
C) The students are able to identify relevant relations between scientific and technological change on the one hand and developments of migration and its control on the other.

Content  
The land border between Mexico and the United States, where the ‘global North’ and the ‘global South’ meet in the most prominent form worldwide, provides an exemplary case to study how borders generate spaces of agency, constitute human communities and create identities – not only by separating people but also by connecting them. The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

Abstract  
This course suggests a framework of analysis for the divergent outcomes of the Arab Uprisings (2011) using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain the disintegration of some countries such as Yemen and Libya and the preservation of states such as Egypt and Tunisia.

Objective  
1. To get an introduction into the politics of the Middle East and North Africa, the Arab Spring and its divergent outcomes
2. To look at the different forms of state formations within the MENA region
3. To investigate how the interaction between types of state formation and regional context shaped current situation in the post Arab Spring MENA region
4. To look closer at Yemeni Civil War

Content  
Countries that experienced popular uprisings in the 2011 Arab Spring had a range of outcomes. Some countries, like Tunisia and Egypt, had a long tradition of centralised state apparatus and a strong national identity. Their outcomes were, respectively, a fragile democratisation process and a reversion to military authoritarianism. Other countries, such as Yemen, Syria and Libya, are newer states that lack a solid national identity, and society is divided along tribal, religious sectarian, linguistic, and/or regional lines. There the outcome has been a meltdown of the political order, along with civil war and fragmentation. Why?

This course suggests a framework of analysis for the divergent outcomes using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain, respectively, the disintegration of countries such as Yemen, Syria and Libya; as well as the preservation of the Bahraini system, despite its ethnic nature. Egypt and Tunisia provide further variants in their well-developed statehood and sense of national identity. Yemen will be used as a case study for examining this complexity among the countries that experienced the Arab Spring.

Abstract  
Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

Objective  
This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe.
In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called "littérature 'nègre'", which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the "négritude", this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.
2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d'Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the "immigration novel".
2:00 – 4:30 pm
Seminar 2:
Guest Mohamed Mbougarr Sarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of "ghettoization". African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.
2:00 – 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of "Noirs en France"
On January 18, 2022, the documentary "Noirs en France" (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the "question of being black" still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.
2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary "Noirs en France".

NB.
The names of the guests in the seminars might change.

★★ Literature

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>851-0084-00L</td>
<td>Sound Studies and Literature – A New Paradigm?</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Alon</td>
</tr>
</tbody>
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Abstract
The lecture presents the methodological diversity of sound studies insofar as they are related to the study of literature and undertakes to critically assess exemplary works. It offers an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.

Is literature silent? The paper pages of the book or the screen of the tablet that we look at while reading might suggest so. Nevertheless, when reading, one cannot help but have the impression that literature contains sound. Doesn't it allow us to identify authors by their "voice," for example, or guide our reading through repetitions and assonances? Does it not seem to reproduce the sonic world?

In other words: How is the relationship between literature and sound to be thought of? In recent years a concept of 'sound' has emerged in the realm of the so-called sound studies which thinks of acoustic phenomena in their connection with human perceptions and actions (Morat/Ziemer 2018). Research in the context of the 'sonic turn' assumes that literature both generates and stores sound and that our understanding of literature should be closely linked to the conceptualization and writing practice of sound as well as the conditions of its production and reception.

Strongly interdisciplinary, this research thus combines perspectives from the cognitive sciences, with approaches from the technical sciences and cultural studies. At times, it has argued to dispense with the traditional fixation on writing and instead to approach literature also through sound practices and listening techniques. These practices and techniques should not only be object of studies, but, employing "listening as a research method" (Holger Schulze), should be integrated into the research methodology.

The lecture will confront the methodological diversity of sound studies insofar as they are related to the study of literature and will undertake to critically assess them. It will offer an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.
In this course we will explore how noise functions both as a threat to meaning and as a source of new order, with special attention to

Science needs to be popularized in order to have an impact on society. Conversely, what is thought, read, and communicated outside the

When is noise—din in the pub, static on the line, attenuation of the signal—a problem for communication? When is noise art? We'll ask

3 credits
P. Gerard
not assessed

No Borders: Galileo, Calvino, Primo Levi

Abstract

Without borders means without disciplinary boundaries, without manuals and school programs that force certain authors to stay "inside" schemes and simplifications. It means freeing oneself from the obligations that certain university systems impose on their students, with the risk of limiting one's view of the great authors Galileo, Italo Calvino and Primo Levi.

Objective

Through the reading and commentary of texts and images, we will narrate the relationship between science and literature, starting from the contexts in which these three authors found themselves living and discussing the problems and issues that each of them had to deal with.

Content

Without borders means without disciplinary boundaries, without manuals and school programs that force certain authors to stay "inside" schemes and simplifications. It means freeing oneself from the obligations that certain university systems impose on their students, with the risk of limiting one's view of the great authors.

This is the case with Galileo, Italo Calvino and Primo Levi. Each of them has been many things at once. The first was a scientist but also a philosopher and expert technologist, a builder of mechanical devices and scientific instruments; the second was a novelist but also an editorial consultant and a refined essayist and literary critic; the third was a chemist, writer and witness to an event that marked the history of the twentieth century.

The course will explore, on the one hand, the central nodes of Galilean science and, on the other, its reception in two "hybrid" authors such as Calvino and Levi. Through the reading and commentary of texts and images, we will narrate the relationship between science and literature, starting from the contexts in which these three authors found themselves living and discussing the problems and issues that each of them had to deal with.

851-0328-00L

No Borders: Galileo, Calvino, Primo Levi

W 3 credits 2V M. Bucciantini

Literature and Knowledge / Science and Fiction

Abstract

Not only the specific genre of "Science Fiction", but fictitious (literary) texts in general are fundamentally about the forms and functions of knowledge and science. In the lecture, these are developed theoretically and discussed using examples.

Objective

1) Introduction to literary theory
2) Theories of science and fiction
3) Introduction to literary scientific knowledge research

Content

Not only the specific genre of "Science Fiction", but fictitious (literary) texts in general are fundamentally about the forms and functions of knowledge and science. In the lecture, this fundamental question of knowledge of literature is developed theoretically and systematically and discussed using examples from science and literature. Contrary to what has long been claimed, more recent theoretical approaches assume that literature is not in conflict with scientific knowledge. Rather, it is part of the social formation, order and negotiation of knowledge. This applies not only to "science fiction" but in general to the "science of fiction", i.e. to the knowledge of literature. In the fictional form of literature, models of knowledge are generated, also with a critical or utopian intention (as in "science fiction"). Moreover, literature draws attention to the central role of representation in the sciences, i.e. to their aesthetic and narrative forms.

851-0311-00L

Literature and Knowledge / Science and Fiction

W 3 credits 2V A. Kilcher

Abstract

Not only the specific genre of "Science Fiction", but fictitious (literary) texts in general are fundamentally about the forms and functions of knowledge and science. In the lecture, this fundamental question of knowledge of literature is developed theoretically and systematically and discussed using examples from science and literature. Contrary to what has long been claimed, more recent theoretical approaches assume that literature is not in conflict with scientific knowledge. Rather, it is part of the social formation, order and negotiation of knowledge. This applies not only to "science fiction" but in general to the "science of fiction", i.e. to the knowledge of literature. In the fictional form of literature, models of knowledge are generated, also with a critical or utopian intention (as in "science fiction"). Moreover, literature draws attention to the central role of representation in the sciences, i.e. to their aesthetic and narrative forms.

851-0336-00L

Popularizing Science. Nonfiction Books Between Academy and Public

W 3 credits 2S I. Barner

Abstract

Science needs to be popularized in order to have an impact on society. Conversely, what is thought, read, and communicated outside the universities has an effect on research. The seminar deals with the history of popular knowledge focusing on the non-fiction book.

Objective

The seminar focuses on the reading and discussion of original and secondary texts on the history of the relationship between knowledge, the book market and the public. Students learn to critically engage with sources as well as research literature from the fields of literary, scientific, and book and media history.

Content

The amount of reading will be limited; what is important above all is the seminar discussion. Cooperation with actors in the literary business (authors, agents, editors, publishers) is planned. The students shall learn to prepare interviews and to write short texts in the form of non-fiction.

851-0360-00L

The Noise of Culture: Literature, Babel, and the Meaning of Meaning

W 3 credits 2V P. Gerard

Abstract

When is noise—din in the pub, static on the line, attenuation of the signal—a problem for communication? When is noise art? We’ll ask James Joyce.

Objective

To gain familiarity with noise as a technical, systems-theoretical, and philosophical concept.

To draw connections between noise as a mythical problem (Babel) and noise as a telecommunications problem.

To apply recent conceptualizations of noise to the interpretation of several works of modern literature.

Content

In this course we will explore how noise functions both as a threat to meaning and as a source of new order, with special attention to literary texts. We will begin with the myth of Babel and look at several central premises of modern literary criticism, including meaning, intention, and representation.

851-0298-00L

The Modern Literary and Artistic Avantgarde in its European Dimension

W 3 credits 2V S. S. Leuenberger

Abstract

The modernist Avant-Garde movements are characterized by a radical rhetoric of apocalypse and rebirth, the genesis of another world and a new mankind. The extension of the "intrinsic logic of the aesthetic form into the social fabric" (H. Ehrlicher), and likewise the intensive examination of the latest technical advancements, new forms of media and their combination, unites them.
Avant-garde movements are characterized by progressive notions on art, social and political issues as well as by radical criticism on the current circumstances. This is why the specific characteristics of the historic avant-garde of the early 20th century will be a central theme of this lecture; they cannot be separated from the experience of modernity, of the catastrophic course of the First World War, and of the concept of new models of society whose political implementation is a major goal after the end of the war.

The lecture is part of the ‘Science in Perspective' course programme aimed at enabling the students to deal with avant-garde texts and artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter Bürger’s assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-criticism".

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic perspective: literary texts and manifests by Heym, van Hoddé, Werfel, Lasker-Schüler, Toller, Marinetti, Ball, Tzara, Huelsenbeck, Hausmann, Apollinaire, Breton, Goll, and others will be read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist Avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of technological innovations, second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and, following the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking resilience to totalitarian ideologies.

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**851-0296-00L**  
**Narrating Time**  
W 3 credits 2S C. Jany

**Abstract**  
It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is inherently narrative and therefore articulated best in the form of narrations. But is it even possible to narrate time? What kind of translation is that? And, above all, what are the costs of, and the resistances to, such a translation?

**Objective**  
The overall aim of this class is to reflect, in theory and through literature, upon the fundamental category of time, the critical insight being that a discretely progressing and uniformly clocked time is only one way of looking at temporal processes. In fact, this standard clock, with which the mathematical sciences calculate and which is mainly used in the technical field, is only a special case, an abstraction for the purpose of more convenient division, measurement and precalculation of time processes. The world, however, also holds more complex experiences of time, which cannot be calculated mathematically or explained by the law of causation alone. Certain experiences of time simply necessitate narration (which is why even in the philosophy of science scholars have come to regard narrative as a legitimate and indeed indispensable means of explanation). Literature makes all this tangible by bringing the uneven clockings, overlaps, and loops of experiential time to light, which still holds true when the literary representation of time fails, i.e., when it becomes clear that the transfer of experienced time into narrated time also entails certain deformations and even losses.

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**851-0345-00L**  
**A Seminar Cycle on Africa**  
W 3 credits 2V A. Mabanckou

**Abstract**  
Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

**Objective**  
This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe.
### Content

In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called "literature ‘nègre’", which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the "négritude", this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d’Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the ‘immigration novel’.

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbougar Sarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of “ghettoization”. African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of “Noirs en France”
On January 18, 2022, the documentary “Noirs en France” (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the “question of being black” still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary " Noirs en France ".

NB.
The names of the guests in the seminars might change.

<table>
<thead>
<tr>
<th>Economics</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0626-01L</td>
<td>International Aid and Development</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>I. Günther</td>
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<tr>
<td>Abstract</td>
<td>The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.</td>
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<tr>
<td>Objective</td>
<td>Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid. Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.</td>
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<td>Content</td>
<td>Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid; e.g. Micro-Finance, Budget-Support; Fair-Trade.</td>
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<tr>
<td>Literature</td>
<td>Articles and book abstracts will be uploaded to a course website.</td>
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<tr>
<td>851-0609-06L</td>
<td>Governing the Energy Transition</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>T. Schmidt</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.</td>
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<tr>
<td>Objective</td>
<td>- To gain an overview of the history of the transition of large technical systems - To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions - To gain knowledge on the role of policy and politics in energy transitions</td>
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<td>Content</td>
<td>Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary. This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.</td>
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<tr>
<td>The grade will be determined by a final exam.</td>
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Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2257 of 2345
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and critical argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

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Literature

The book can also be used for the course ‘Principles of Macroeconomics’ (Sturm)

For students taking only the course ‘Principles of Microeconomics’ there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Taught competencies

Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: not assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: assessed
Media and Digital Technologies: not assessed
Problem-solving: assessed
Project Management: not assessed

Social Competencies
Communication: not assessed
Cooperation and Teamwork: not assessed
Customer Orientation: not assessed
Leadership and Responsibility: not assessed
Self-presentation and Social Influence: assessed
Sensitivity to Diversity: not assessed
Negotiation: not assessed

Personal Competencies
Adaptability and Flexibility: not assessed
Creative Thinking: not assessed
Critical Thinking: assessed
Integrity and Work Ethics: not assessed
Self-awareness and Self-reflection: assessed
Self-direction and Self-management: not assessed

363-0565-00L Principles of Macroeconomics

W 3 credits 2V J.-E. Sturm

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature
The set-up of the course will closely follow the book of
This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: not assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: assessed
Media and Digital Technologies: not assessed
Problem-solving: assessed
Project Management: not assessed

Social Competencies
Communication: not assessed
Cooperation and Teamwork: not assessed
Customer Orientation: not assessed
Leadership and Responsibility: not assessed
Self-presentation and Social Influence: assessed
Sensitivity to Diversity: not assessed
Negotiation: not assessed

Personal Competencies
Adaptability and Flexibility: not assessed
Creative Thinking: not assessed
Critical Thinking: assessed
Integrity and Work Ethics: not assessed
Self-awareness and Self-reflection: assessed
Self-direction and Self-management: not assessed

363-0561-00L Financial Market Risks

Does not take place this semester.

W 3 credits 2G not available

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Abstract
I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

Objective
The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

- Development of the concepts and tools to understand these risks and master them.
- Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)
- Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks

Content
1. The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of he perpetual money machine.

2. Risks in financial markets
- What is risk?
- Measuring risks of financial assets
- Introduction to three different concepts of probability
- History of financial markets, diversification, market risks

3. Introduction to financial risks and its management.
- Relationship between risk and return
- Portfolio theory: the concept of diversification and optimal allocation
- How to price assets: the Capital Asset Pricing Model
- How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4. Financial markets: role and efficiency
- What is an efficient market?
- Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
- Deviations from efficiency, puzzles and anomalies in the financial markets
- Financial bubbles, crashes, systemic instabilities

5. An introduction to Options and derivatives
- Calls, Puts and Shares and other derivatives
- Financial alchemy with options (options are building blocs of any possible cash flow)
- Determination of option value; concept of risk hedging

6. Valuation and using options
- A first simple option valuation model
- The Binomial method for valuing options
- The Black-scholes model and formula
- Practical examples and implementation
- Realized prices deviate from these theories: volatility smile and real option trading
- How to imperfectly hedge with real markets?

7. Real options
- The value of follow-on investment opportunities
- The timing option
- The abandonment option
- Flexible production
- Conceptual aspects and extensions

8. Government bonds and their valuation
- Relationship between bonds and interest rates
- Real and nominal rates of interest
- Term structure and Yields to maturity
- Explaining the term structure
- Different models of the term structure

9. Managing international risks
- The foreign exchange market
- Relations between exchange rates and interest rates, inflation, and other economic variables
- Hedging currency risks
- Currency speculation
- Exchange risk and international investment decisions

Lecture notes
Lecture slides will be available on the site of the lecture

Literature
Corporate finance Brealey / Myers / Allen

Prerequisites / notice
None

351-0555-00L Open- and User Innovation W 3 credits 2G S. Häfliger, S. Spaeth
Not for students belonging to D-MTEC!

Abstract
The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through this they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.
The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active class participation is required.

This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

The slides of the lectures are made available and updated continuously through the SMI website:

**Environment Policy of Switzerland**

Number of participants limited to 130.

Beyond acquiring basic knowledge about public policy analysis, this course teaches students how to analytically address current and concrete questions of environmental policy. Through exercises the students learn about political science concepts and frameworks as well as real-life political decision-making processes. The well-grounded examination of complex political conflict situations is an important precondition for the entry into the (environmental policy) workforce or a future research career.

The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

The detailed semester program (syllabus) is made available to the students at the beginning of the semester.

During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.

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During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.
Introduction to Microeconomics

**GESS (Science in Perspective):**
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend “Principles of Microeconomics” (LE 363-0503-00L) instead.

**Note for D-MAVT students:** If you have already successfully completed “Principles of Microeconomics” (LE 363-0503-00L), then you will not be permitted to attend it again.

**Abstract**
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

**Objective**
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real-world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

**Content**
- Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

**Lecture notes**
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

**Literature**

**Prerequisites / notice**
This course “Einführung in die Mikroökonomie” (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 “Principles of Microeconomics” for Master students.

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## Philosophy

### 851-0180-00L Research Ethics

- **Title:** Research Ethics
- **Type:** W
- **ECTS:** 2 credits
- **Hours:** 2G
- **Lecturers:** G. Achermann, P. Emch

**Number of participants limited to 40**

**Number of participants limited to 40**

**Abstract**
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

**Objective**
Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

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**Data:** 18.08.2022 12:39  
**Autumn Semester 2022**  
**Page 2262 of 2345**
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Environmental Ethics

The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.
Science and technology are projects that are usually described as “progressing”. Earlier findings and inventions are used to create new World Views in the Digital Age. The students apply philosophical conceptions of ignorance and error to sciences and their own studies.

Ignorance and Error in the Sciences

Students learn about the different types of argumentative texts and their historical context. They learn to understand the descriptive and objective: 
- to introduce students to the philosophical dimension of science; 
- to develop a critical understanding of scientific rationales; 
- to acquire skills in order to read and comment on scientific texts written in the past ages.

Content

The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.

Democracy (Theory) and Challenges Posed by the Digital Transformation

Objective

- Students will gain an overview of different theories of democracy and the associated different types of challenges to democracy posed by the digital transformation of society. They will be enabled to interpret complex texts, to identify the argumentation, to reflect critically and to put it up for discussion.

Content

Researchers agree that the digital transformation of society is a challenge to democracy. What is disputed is how exactly it challenges or even endangers it. One reason for the disagreement is certainly due to different descriptions and assessments of the precise social effects and risks of various digital technologies. A second reason has to do with the diversity of theories of democracy. In democratic theory, a distinction is usually made between liberal, republican, pluralist-participatory, and deliberative models of democracy (and often many more). Depending on which model is used (and how exactly it is determined), political participation, elections, accountability of politicians, the role of central legal-political institutions (such as the constitution), political culture, and the quality of discourse in the public sphere are conceived and evaluated differently.

In a first step, this seminar will provide an overview of different theories of democracy, with the aim of making explicit the normative features of important elements of democracy (such as political participation). In a second step, examples of the social application of digital technologies are used to discuss both divergent descriptions of their impact and controversies about normative evaluations in the research literature. In a third step, these dissents are related to the models of democracy elaborated in the first part and analyzed.

Ignorance and Error in the Sciences

Objective

- The students apply philosophical conceptions of ignorance and error to sciences and their own studies.
- The students reflect ignorance and error in their own scientific practice.
- The students discuss controversial positions in an interdisciplinary context.

Content

In this seminar we will analyze and discuss the different roles of ignorance and error in sciences from a philosophical perspective.

War between Humans, or War against Nature?

Objective

Students learn about the different types of argumentative texts and their historical context. They learn to understand the descriptive and critical value of texts in regard to the topic of war.

Progress

Objective

Acquire knowledge of basic concepts of progress and their evaluation options.

Content

The U.S. philosopher Chauncey Wright wrote in 1865 in his critique of the famous 19th century popular philosopher Herbert Spencer: “Progress is a grand idea, – Universal Progress is a still grander idea. It strikes the key note of modern civilization. Moral idealism is the religion of our times. What the ideas of God, the One, and the All, the Infinite First cause, were to an earlier civilization, such are Progress and Universal Progress to the modern world, – a reflex of its moral ideas and feelings.” (Chauncey Wright, The Evolutionary Philosophy.... Vol. 1. 2000, S. 69). The lecture will give an introduction into the different concepts of progress and try to evaluate them against the background of the current epistemological situation.

Pluralist Philosophy of Mathematics

Objective

This course will follow Michèle Friend's book "pluralism in mathematics". It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.
The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions. The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralist and paraconsistent philosophical approaches.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<td>851-0092-00L</td>
<td>Artifical vs Human?</td>
<td>3</td>
<td>W</td>
<td>L. Wingert</td>
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<tr>
<td>851-0093-00L</td>
<td>Ethical Issues in the Economy</td>
<td>3</td>
<td>W</td>
<td>L. Wingert</td>
</tr>
<tr>
<td>851-0296-00L</td>
<td>Narrating Time</td>
<td>3</td>
<td>W</td>
<td>C. Jany</td>
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<tr>
<td>851-0354-00L</td>
<td>Withdrawal Symptoms, Phenomenology and Religion According to Bernard Waldenfels (UZH)</td>
<td>3</td>
<td>W</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0352-00L</td>
<td>Introductory Course in Philosophy of Religion (University of Zurich)</td>
<td>3</td>
<td>W</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Objective
The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralist and paraconsistent philosophical approaches.

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The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralist and paraconsistent philosophical approaches.

Taught competencies

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concept and Theories</th>
<th>assessed</th>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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Abstract
KI-based machines and artificial agents are playing more and more a crucial role in our social and political life. Do they essentially differ from human intelligence and human actors or are they merely an (advanced) version of us? How should we judge on their role? For answering such questions one has to give an account of essential features of intelligence, reason, and agency.

Objective
Participants should learn to know some philosophical accounts of intelligence, reason, and agency. This knowledge should enable them to evaluate the pro and con of answers to questions of the following kind:
1. Is human deliberation and argumentation essentially algorithmic?
2. Is AI confined to smart solutions of given problems or is AI also able to revise the framing of problems?
3. Could artificial agents like robots be responsible for their behavior?
4. Do my smartphone and I constitute an extended, hybrid mind?
5. How should we deal with AI-based machines in our social and political life?

Ethical Issues in the Economy
The course offers an introduction to analytical, phenomenological and hermeneutic philosophy of religion. Influential positions, vital philosophical approach and ask how life-worldly alien-experiences relate to and are interconnected with scientific experience. On this basis, behavior. To elucidate this logic of answering in human experience is the leading goal of the 'responsive phenomenology' developed by familiar. the sciences. The alien, however, only 'exists' starting from the own, it appears by withdrawing itself within the sphere of the own and experienced time into narrated time also entails certain deformations and even losses.

experiential time to light, which still holds true when the literary representation of time fails, i.e., when it becomes clear that the transfer of experiences of time, which cannot be calculated mathematically or explained by the law of causation alone. Certain experiences of time indeed indispensable means of explanation). Literature makes all this tangible by bringing the uneven clockings, overlaps, and loops of purpose of more convenient division, measurement and precalculation of time processes. The world, however, also holds more complex circumstances or favorable conditions? And what follows from the answer for the judgment on social inequalities?

9. Do we need a de-globalization of doing economics?

Abstract
It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is inherently narrative and therefore articulated best in the form of narrations. But is it even possible to narrate time? What kind of translation is that? And, above all, what are the costs of, and the resistances to, such a translation?

Objective
The overall aim of this class is to reflect, in theory and through literature, upon the fundamental category of time, the critical insight being that a discretely progressing and uniformly clocked time is only one way of looking at temporal processes. In fact, this standard clock, with which the mathematical sciences calculate and which is mainly used in the technical field, is only a special case, an abstraction for the purpose of more convenient division, measurement and precalculation of time processes. The world, however, also holds more complex experiences of time, which cannot be calculated mathematically or explained by the law of causation alone. Certain experiences of time simply necessitate narration (which is why even in the philosophy of science scholars have come to regard narrative as a legitimate and indeed indispensable means of explanation). Literature makes all this tangible by bringing the uneven clockings, overlaps, and loops of experiential time to light, which still holds true when the literary representation of time fails, i.e., when it becomes clear that the transfer of experienced time into narrated time also entails certain deformations and even losses.

Abstract
One can differentiate the same and the other looking at them from a third standpoint, ‘from outside’ – a methodological approach typical for the sciences. The alien, however, only ‘exists’ starting from the own, it appears by withdrawing itself within the sphere of the own and familiar.

Objective
Alien-experiences thus are withdrawal symptoms and phenomena. In alien-experiences, we encounter a call we have to respond to in our behavior. To elucidate this logic of answering in human experience is the leading goal of the ‘responsive phenomenology’ developed by Bernard Waldenfels. In collaborative reading and discussion, the introductory seminar aims to profile the main features of this innovative philosophical approach and ask how life-worldly alien-experiences relate to and are interconnected with scientific experience. On this basis, we will ask how this ‘responsive phenomenology’ can help to map guiding differences in religion (e.g. immanence – transcendence) and religious phenomena (e.g. revelation) in a philosophical perspective and thus to decipher (and relate) the rationalities behind religious and scientific worldviews.

Abstract
The course offers an introduction to analytical, phenomenological and hermeneutic philosophy of religion. Influential positions, vital questions and significant developments will be discussed and critically reflected.
**Objective**
Special emphasis will be placed on the relationship between religious and scientific discourse in the 20th century. To get a better grasp of the complexity of this relationship, different narratives will be examined as to how the modern ideal of modelling all cognitive values on scientific ones came to exert supreme authority in Western societies. The still prevalent, mainstream view has deep roots in 19th century positivism, which assumed a necessary historical progress from religion to metaphysics to science. In this perspective, scientific knowledge uncovers ‘objective’ reality by displacing superstition and more ‘primitive’, mythical or metaphysical accounts of human and cosmic origins. On the other hand, there is the more recent, ‘heterodox’ view advanced by philosophers and historians of science like S. Gaukroger, that the success of science in the West in the early-modern era might be related to its close association with theology rather than attempts to emancipate itself from it. The question here arises: What traditional ideas of God and religious faith contributed to the modern ideal of knowledge and truth – an ideal which, in a strange twist of historical irony, finally led to the seeming exclusion of all religious discourse from the properly scientific quest for real knowledge and truth in present-day secular societies?

**376-1661-00L**

**Ethics of Life Sciences and Biotechnology**

*Number of participants limited to 100*

**Abstract**
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

**Objective**
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

**Content**
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

**851-0345-00L**

**A Seminar Cycle on Africa**

**Abstract**
Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

**Objective**
This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe.
In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called "littérature ‘nègre’", which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the "négritude", this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d'Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the ‘immigration novel’.

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbougar Sarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of “ghettoization”. African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of "Noirs en France"
On January 18, 2022, the documentary "Noirs en France" (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the "question of being black" still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary " Noirs en France ".

NB.
The names of the guests in the seminars might change.

★★ Political Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0589-00L</td>
<td>Technology and Innovation for Development</td>
<td>W Dr</td>
<td>3 credits</td>
<td>2V</td>
<td>P. Aerni</td>
</tr>
</tbody>
</table>

Abstract
Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

Objective
- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content
Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies.

The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes
Reader with issue-specific articles. E-version is partly available on Moodle
Students will receive a handout of slides accompanying the lectures.


In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion


Romer, P. 2020. What It Takes To Be a Leader in Both Basic Science and Technological Progress. Statement for House Budget Committee Hearing on Federal R&D (https://paulromer.net/statement-for-house-budget-committee/)


Aerni, P. (2021a) 'The ethics of farm animal biotechnology from an anthropological perspective'. Sustainability 13(7), 3674.

Aerni, P. (2021b) 'Decentralized economic ecosystems in Switzerland and their contribution to inclusivity and sustainable change'. Sustainability 13(8), 4181


Aerni, P. 2016a. Coping with Migration-Induced Urban Growth: Addressing the Blind Spot of UN Habitat. Sustainability 8(800)


853-0038-00L Swiss Foreign Policy

W 3 credits 2V D. Möckli

Abstract
This course analyzes the foundations and challenges of Swiss foreign policy. After reviewing the history of foreign policy conceptions since the early 20th century, we will discuss the determining factors of Swiss foreign policy and examine, together with guest speakers from the foreign ministry, current international developments and respective foreign policy challenges.

Objective
Students should acquire a sound understanding of Swiss foreign policy and the relevant academic and political debates associated with it.

Content

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester.

The class will be taught in English.

Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

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### Taught competencies

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### 853-0015-01L Conflict Research I: Political Violence

**W 3 credits 2V**  
A. Juon, Y. Weissberg

**Abstract**  
Introduction to research on political violence in domestic and international politics. This course covers the causes and solutions to different types of political violence including interstate wars, civil wars, terrorism or social protests.

**Objective**  
Knowledge on different types of political violence and their causes.

**Content**  
This course offers an introduction to research on the causes and solutions to political violence in domestic and international politics. First, we discuss the definitions and concepts used in conflict research, the data and methods commonly applied and their historical development. Second, we focus on interstate wars and examine in this context state formation, nationalism and democracy. The third part of the course focuses on different types of political violence, including civil war, terrorism or social protests.

**Prerequisites / notice**  
The course «Conflict Research II» in the following semester further examines civil wars.

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### 853-0302-01L European Integration (Seminar without Tutorial)

**W 2 credits 2S**  
R. Sczepanski

**Abstract**  
The lecture course covers the theory, development, and core policy fields of European integration as well as structures and processes of the EU as a decision- and policy-making system.

**Objective**  
The seminar is designed to help students understand the European Union as a particular kind of political system that differs both from the nation-state and from other international organizations. It imparts basic knowledge on the development, institutions, procedures, and policies of the EU and provides an introduction to major approaches to integration theory and political science research on the EU.

**Content**  
1. Introduction  
2. Theories of European integration  
3. Institutional development of European integration  
4. Development of political integration  
5. Internal market and monetary union  
6. Internal and external security policies  
7. Constitutionalization  
8. Widening and differentiation  
9. European integration in crisis  
10. Institutions  
11. Law-making and law enforcement  
12. Statehood and democracy  
13. Switzerland, the EEA and Neighbourhood Policies

**Lecture notes**  
The seminar covers the theory, development, and core policy fields of European integration as well as structures and processes of the EU as a decision- and policy-making system.

**Literature**  
Die Literatur wird auf Moodle bereitgestellt.

**Prerequisites / notice**  
The grade is based on a written exam.

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### 860-0023-00L International Environmental Politics

**Particularly suitable for students of D-ITET, D-USYS**  
W 3 credits 2V  
T. Bernauer

**Abstract**  
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

**Objective**  
The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental policies are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Literature
Reading materials and slides will be available via Moodle.

Lecture notes
Reading materials and slides will be available via Moodle.

Prerequisites / notice
This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

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### Introduction to Cybersecurity Politics

**853-0061-00L**

**Abstract**

The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

**Objective**

Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.

**Content**

We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

**Lecture notes**

A script with background information and comments on the literature will be made available at the beginning of the semester.

**Literature**

Literature for each session will be available on Moodle.

**Prerequisites / notice**

The lecture is being supported by a website on Moodle.

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### The Role of Technology in National and International Security Policy

**853-8002-00L**

**Abstract**

The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

**Objective**

Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

**Content**


**Literature**

Literatur für die einzelnen Sitzungen wird auf Moodle bereitgestellt.

**Prerequisites / notice**

The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos,

oliver.roos@sipo.gess.ethz.ch.

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### AI4Good

**853-0650-00L**

**Abstract**

The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

**Objective**

Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0101-74L

Abstract Sustainable Development - Bridging Art and Science W 3 credits 2G S. Patel, J. Neve

In this course students deepen their knowledge about global development and sustainability issues. We will show five movies each of them linked to one of the five P’s (Planet, People, Prosperity, Peace and Partnerships) reflecting the topics of the 2030 Agenda. Afterwards the movie will be critically discussed with researchers and relevant stakeholders from the broader society.

Objective

- Students get a broad understanding of some of the most important issues and discussions related to sustainable development.
- Students get exposed to diverse realities of young people in developing countries.
- Students reflect on issues concerning communicating research and the realities of low-income settings to a wider public.

Content

The aim of the course is to deepen student’s knowledge about global issues and to inspire them to reflect critically upon complex topics, which are related to the broad topic of sustainable development. In each class, we show a documentary film, which is linked to one of the five critical areas of the 2030 Agenda (Planet, People, Prosperity, Peace and Partnerships), putting specific focus on realities in developing countries. Following the movie screenings, we will discuss the topic of the film in the light of sustainable development with an expert from academia and/or a practitioner from the field of development cooperation. In preparation for each class, the students read an academic paper, which will also be considered in the discussion. The idea of “Bridging Art and Science” is to expose an interdisciplinary group of students to artistic and scientific perspectives alike and to challenge them to deal with bias and polarization, and the role that the media and films play in that regard. The participants of the course will be given the chance to embrace the complexity of sustainable global development.

851-0534-00L

Yemeni Civil War: The Arab Spring, State Formation and Regional Rivalry

Abstract

This course suggests a framework of analysis for the divergent outcomes of the Arab Uprisings (2011) using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain the disintegration of some countries such as Yemen and Libya and the preservation of states such as Egypt and Tunisia.

Objective

1. To get an introduction into the politics of the Middle East and North Africa, the Arab Spring and its divergent outcomes.
2. To look at the different forms of state formations within the MENA region.
3. To investigate how the interaction between types of state formation and regional context shaped current situation in the post Arab Spring MENA region.
4. To look closer at Yemeni Civil War.

Content

Countries that experienced popular uprisings in the 2011 Arab Spring had a range of outcomes. Some countries, like Tunisia and Egypt, had a long tradition of centralised state apparatus and a strong national identity. Their outcomes were, respectively, a fragile democratisation process and a reversion to military authoritarianism. Other countries, such as Yemen, Syria and Libya, are newer states that lack a solid national identity, and society is divided along tribal, religious sectarian, linguistic, and/or regional lines. There the outcome has been a meltdown of the political order, along with civil war and fragmentation. Why?

This course suggests a framework of analysis for the divergent outcomes using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain respectively, the disintegration of countries such as Yemen, Syria and Libya; as well as the preservation of the Bahraini system, despite its ethnic nature. Egypt and Tunisia provide further variants in their well-developed statehood and sense of national identity. Yemen will be used as a case study for examining this complexity among the countries that experienced the Arab spring.

Psychology, Pedagogics

Number | Title |
--- | --- |
851-0240-00L | Human Learning (EW1) |

Abstract

This lecture is only apt for students who intend to enrol in the programs “Teaching Diploma” or “Teaching Certificate”. It is about learning in childhood and adolescence.

Objective

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content

Thematic Schwerpunkte:
- Lernen als Verhaltensänderung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzentwicklung unter besonderer Berücksichtigung des Wissenstransfer; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Intervallindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede

Lernformen:

Lecture notes

Foliendruck wird verwendet.

Literature


Prerequisites / notice

This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.
In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**
The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students’ misconceptions.

**Content**
We learn from our mistakes, or rather, we hope that we do. Another way to say this is that we can learn from failure. But, what does “failure” mean? And, why do we do learn from failure? This course covers research from the cognitive, educational, and learning sciences that addresses the role of failure in human learning. Students will critically examine how failure affects thinking, knowledge, creativity, problem-solving, and motivation.

By the end of the course, students should be able to:
- Demonstrate a critical understanding of the role that failure plays in learning
- Discuss how and why failure can benefit learning
- Discuss how and why failure does not facilitate learning
- Apply understanding to a related sub-topic

**Prerequisites / notice**
This seminar is an interactive course, thus attendance and classroom participation are required. Processing of online tasks is a requirement for obtaining credit points.

**Taught competencies**
The course is held as 2 separate courses with each a maximum of 30 students: one course in German and one course in English.

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**Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the “Teaching Diploma”.

**Prerequisites:** successful participation in 851-0240-00L “Human Learning (EW1)”.

**Support and Diagnosis of Knowledge Acquisition Processes (EW3)**

**Number of participants limited to 35.**

**Human-Computer Interaction: Cognition and Usability**

**Number of participants limited to 60.**

**The Science of Learning from Failure**

**Number of participants limited to 60.**

**Psychological Aspects of Risk Management and Technology**

**Number of participants limited to 35.**

Data: 18.08.2022 12:39  Autumn Semester 2022  Page 2272 of 2345
Number of participants limited to 65.

Abstract
Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are treated. Three components of risk management (risk identification/evaluation, risk mitigation, risk communication) and underlying psychological and organizational processes are discussed, using company case studies to promote in-depth understanding.

Objective
- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organizations
- Know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

Content
The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

Lecture notes
There is no script, but slides will be made available before the lectures.

Literature
There are texts for each of the course topics made available before the lectures.

Prerequisites / notice
The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

701-0721-00L Psychology
This course provides an introduction to psychological research and modelling, focusing on cognitive psychology and the psychological experiment. Participants learn to formulate problems for psychological investigation and apply basic forms of psychological experiment.

Objective
Students are able to
- describe the areas, concepts, theories, methods and findings of psychology.
- differentiate scientific psychology from “everyday” psychology.
- structure the conclusions and significance of an experiment according to a theory of psychology.
- formulate a problem for psychological investigation.
- apply basic forms of psychological experiment.

Content
Einführung in die psychologische Forschung und Modellbildung unter besonderer Berücksichtigung der kognitiven Psychologie und des psychologischen Experiments. Themen sind u.a.: Wahrnehmung; Lernen und Entwicklung; Denken und Problemlösen; Kognitive Sozialpsychologie; Risiko und Entscheidung.

Evidenc-Based-Based: Methods and Tools for Evaluating Architectural Design
851-0252-08L

Objective
Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

Objective
The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

Objective
To introduce students to the basics of consciousness studies, and to thus help them to gain a deeper understanding of how the mind works. Includes practical implications for the scientific mind.
Content

The study of consciousness involves scholars from diverse fields, such as psychology, neuroscience, cognitive science, philosophy, linguistics, computer science, medicine, religious studies, anthropology, as well as literature and art studies. While the study of consciousness is presented mainly from the point of view of psychology in this course, additional interdisciplinary viewpoints are also integrated.

Psychological consciousness studies involve research on levels and states of consciousness. Psychologically researched levels of consciousness are the conscious, preconscious, unconscious/subconscious, and nonconscious levels of mental processing. Psychological research on states of consciousness – which is the main focus of this course – takes waking consciousness as the most common state (ordinary state of consciousness, OSC), using it as a baseline against which altered states of consciousness (ASCs) are compared. Some of the most prominently or promising researched ASCs in psychology will be introduced in this course and include sleeping/dreaming, hypnosis, meditation, sensory deprivation (e.g., floating tank), rhythm-induced trance, as well as ASCs induced by psychoactive drugs (classic psychedelics, dissociative anesthetics, empathogens). Furthermore, it will also be shown how a growing number of health and clinical studies investigate the therapeutic potential of being temporarily in an ASC. Finally, in this course, two mental phenomena that are also highly relevant for the scientific mind – insight and flow – are also introduced from a consciousness-studies perspective.

**851-0252-02L**  
**Introduction to Cognitive Science**  
*W 3 credits 2V C. Hölscher*  

Abstract

The lectures provide an overview of the foundations of cognitive science and investigate processes of human cognition, especially perception, learning, memory and reasoning. This includes a comparison of cognitive processes in humans and technical systems, especially with respect to knowledge acquisition, knowledge representation and usage in information processing tasks.

Objective

Cognitive Science views human cognition as information processing and provides an inter-disciplinary integration of approaches from cognitive psychology, informatics (e.g., artificial intelligence), neuroscience and anthropology among others. The lectures provide an overview of basic mechanisms of human information processing and various application domains. A focus will be on matters of knowledge acquisition, representation and usage in humans and machines. Models of human perception, reasoning, memory and learning are presented and students will learn about experimental methods of investigating and understanding human cognitive processes and representation structures.

**851-0253-08L**  
**Advanced Topics in Evidence-Based Design for Architecture**  
*Course requirements: Completion of the course Evidence-Based Design: Methods and Tools For Evaluating Architectural Design (851-0252-08L)*  

Abstract

Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layout from the perspective of end-users.

Objective

Students will build on their previous projects as part of the course "Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University designing the post-pandemic hospital with evidence for people. The course is funded by an ETH innovedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

**851-0252-60L**  
**Informal Learning Spaces**  
*W 3 credits 2S C. Hölscher*  

Abstract

This course is for D-ARCH students taking the Informal Learning Spaces Design Studio. Students develop their studio project to gain a better understanding of how users behave in that space. Supported by a theoretical foundation in spatial cognition, students observe, analyse and document how their case study is used by others.

Objective

The aim of the seminar is for students to engage with what makes a good learning space. Students develop the intervention proposed in the design studio. By observing and documenting how other students interact with their interventions, students will be able to answer questions about what makes a good learning space for ETH students.

Content

What makes a good learning space? How does this differ for students from different disciplines? This interdisciplinary seminar addresses the design of learning spaces by combining methods from architecture and psychology.

Students are taught formal methods of behavioural observation so that they can observe and analyse how their intervention is used by others (students, faculty, visitors) over time. By collecting behavioural data on how their intervention is used, students will be able to assess the impact of their design on other users. The seminar encourages students to critically reflect on what elements are necessary for designing the learning spaces of the future.

Prerequisites / notice

Access to the course is restricted to D-ARCH students of the Informal Learning Spaces Design Studio.

**851-0345-00L**  
**A Seminar Cycle on Africa**  
*W 3 credits 2V A. Mabanckou*  

Abstract

Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

Objective

This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe.
In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called "littérature ‘nègre’", which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the "négritude", this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d'Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the 'immigration novel'.

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbougarr Sarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of "ghettoization". African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3:
Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of "Noirs en France"
On January 18, 2022, the documentary “Noirs en France” (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the “question of being black” still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary " Noirs en France ".

NB.
The names of the guests in the seminars might change.
Students who have attended or will attend the lecture "Introduction to Law for Civil Engineering and Architecture" (851-0703-03L) or "Introduction to Law" (851-0708-00L), cannot register for this course unit.

Abstract
This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Objective
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

Content
Basic concepts of law, sources of law.
Private law: Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.
Insights into the law of the EU and into criminal law.

Lecture notes
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

851-0742-00L
Contract Design I
This course is taught by Professor Alexander Stremitzer (https://lawconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Contract Design I (851-0742-00L; Fall 2022)" and enroll. The password is "ContractDesign01".

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Abstract
Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Objective
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Lecture notes
Handouts, prerecorded videos, slides, and other materials

Prerequisites / notice
Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

851-0703-04L
Law and Urban Space
Particularly suitable for students of D-ARCH

Abstract
Legal rules are tied to urban space. Illustrative is the relation between land ownership and urban morphology or between zoning and the functional dimension of urban space. Legal concepts (from property law, fundamental rights and administrative law) with spatial impacts are introduced and related to the theory of urban design. Moreover, it is discussed how these concepts shape specific places.
Objective
Students recognize the interplay between legal structures and urban space. They can describe legal concepts with spatial impact. Moreover, they are able to compare legally binding targets with theoretical approaches in urban design. By analysing specific places, students learn to find relevant norms, to analyse and to judge them with regard to urban design theories. Thereby, they are able to distinguish design and policy questions.

Content
Using the the term "lowscape" (Philippopoulous-Mihalopoulos), we initially discuss general aspects of the interplay between legal rules and urban space.

The first part of the course is about the morphological dimension of urban space. We compare positions of urban planners like Trancik (Urban Space) or Rowe/Koetter (Collage City) with property law. Freedom of property in turn contrasts to the theoretical approaches of Bernoulli (Die Stadt und ihr Boden) or Rossi (L'architettura della città). Using court decisions concerning nail houses, we study the tensions between urban development and the system of property ownership.

The second part of the course is about the functional dimension of urban space. Key concept is the zone (cf. CIAM 4). This concept is criticized (Wolftrum, Zoning Bien Défini). We compare the concept as well as the critique with the main concerns in spatial planning law. Environmental law and neighbouring rights are also relevant.

In the third part of the course, we work on the social, visual and temporal dimensions of urban space. The positions of Jacobs (The Death and Life of Great American Cities), Cullen (Townscape) or Lynch (The Presence of the Past) are compared with the dichotomy public space/private space, safety regulations, regulations on design reviews or heritage protection laws.

Working tools are theoretical texts, legal rules, court decisions as well as site analyses. Students undertake a case study in small groups. Selected case studies are presented and discussed in a final meeting.

Lecture notes
See Literature.

Literature
Documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17513).

851-0707-00L Space Planning Law and Environment

Objective
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

851-0709-00L Introduction to Civil Law

Objective
Teaching of the principles of law, particularly private law. Introduction to law.

Content
Le cours de droit civil porte notamment sur le droit des obligations (droit des contrats et responsabilité civile) et sur les droits réels (propriété, gages et servitudes). De plus, il est donné un bref aperçu du droit de la procédure et de l'exécution forcée.

Literature
Editions officielles récentes des lois fédérales, en langue française (Code civil et Code des obligations) ou italienne (Codice civile e Codice delle obbligazioni), disponibles auprès de la plupart des librairies.

Prerequisites / notice
- Courses of Civil Procedure and Enforcement.

851-0727-02L E-Business-Law

Objective
The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.

The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.
Objective
The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes
A comprehensive script will be made available online on the moodle platform.

Number of participants limited to 100

Particularly suitable for students of D-ITET, D-MAVT

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

Prerequisites / notice
Die Semestertprüfungen war vor Corona in Form eines schriftlichen Kurztests (normalerweise ein MC, im letzten Jahr Coronabedingt aber eine Falllösung) in der letzten Doppelstunde ausgestaltet. Es wird angegeben, welche Unterlagen beim jeweiligen Thema den Prüfungsstoff definieren. Der Test wird möglicherweise elektronisch durchgeführt.

Prüfungsstoff definieren. Der Test wird möglicherweise elektronisch durchgeführt.

851-0738-000L Intellectual Property: Introduction
W 2 credits 2V M. Schweizer

Abstract
The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

Objective
The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

Lecture notes
Weiterführende Materialien, Links und Literatur sind auf dem Termin- und Themenplan aufgeführt (zu gegebener Zeit abrufbar via elektronische Dokumentenablage).

Prüfungsstoff definieren. Der Test wird möglicherweise elektronisch durchgeführt.

851-0735-10L Law for Entrepreneurs
Number of participants limited to 100

Abstract
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective
The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes
Es wird mit Folien gearbeitet, die als PDF über die elektronische Dokumentenablage (ILIAS) auf dem System der ETHZ vorgängig abrufbar.

Der Termin- und Themenplan ist zu gegebener Zeit über die elektronische Dokumentenablage abrufbar.

Prüfungsstoff definieren. Der Test wird möglicherweise elektronisch durchgeführt.

Topic covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks. The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models. We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

**851-0760-00L** Building a Robot Judge: Data Science for Decision-Making

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work. Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

Some programming experience in Python is required, and some experience with text mining is highly recommended. Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course. We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.

**851-0761-00L** Building a Robot Judge: Data Science for Decision-Making (Course Project)

This is the optional course project for "Building a Robot Judge: Data Science for the Law."

Please register only if attending the lecture course or with consent of the instructor.

Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

**851-0742-01L** Contract Design II

This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).

To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.

**851-0724-01L** Real Estate Property Law

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work. Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

Some programming experience in Python is required, and some experience with text mining is highly recommended. Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.
The planned course outline is below

**Course Title:** Project in Behavioural Finance

**ECTS:** 3 credits

**Type:** 2S

**Lecturers:** S. Andraszewicz, C. Höltscher, A. C. Roberts

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

The planned course outline is below

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

**Sociology**

**Number**

<table>
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<th>ECTS</th>
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<td>3</td>
<td>2S</td>
<td>S. Andraszewicz, C. Höltscher, A. C. Roberts</td>
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 Particularly suitable for students of D-MTEC

This course has four main goals:
1) To learn about the most important topics within Behavioural Finance
2) To learn how to conduct behavioural studies, design experiments, plan data collection and experimental tasks
3) To learn about causes of market crashes, factors that influence them, traders' behaviour before, during and after financial crises
4) To investigate a topic of interest, related to behaviour of traders during market crashes.

Additionally, the course gives to the students the opportunity to practice oral presentations, communication skills, report writing and critical thinking.

The course provides an overview of the most important topics in Behavioural Finance. First part of the course involves reading scientific articles, which will be discussed during the seminar. Therefore, attendance is required to pass the course. Each week, a student volunteer will present a paper and the presentation will be followed by a discussion. After obtaining sufficient knowledge of the field, students will select a topic for a behavioural study of their own. The final assignment consists of preparing and conducting a small behavioural study/experiment, analysing the data and presenting the project in the final meeting of the class. Each student will write a scientific report of their study.
Network Modeling

Particularly suitable for students of D-INFK and in the MSc Data Science

Students are required to have basic knowledge in inferential statistics, such as regression models.

Abstract

Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective

Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and tests those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and develop an understanding of how those can be fit to empirical data. This will enable students to independently address research questions from various social science fields.

Content

The following topics will be covered:

- Introduction to network models and their applications
  - Stylized models:
    * uniform random graph models
    * small world models
    * preferential attachment models
  - Models for testing hypotheses while controlling for the network structure:
    * Quadratic assignment procedure regression (QAP regression)
  - Models for testing hypotheses on the network structure:
    * Models for one single observation of a network: exponential random graph models (ERGMs)
    * Models for panel network data: stochastic actor-oriented models (SAOMs)
    * Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes

Slides and lecture notes are distributed via the associated course moodle.

Literature


Prerequisites / notice

Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

Network Analysis

Particularly suitable for students of D-INFK, D-MATH

Abstract

Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Objective

Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

Content

The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

- Empirical Research and Network Data
- Macro and Micro Structure
- Centrality
- Roles
- Cohesion

Lecture notes

Lecture notes are distributed via the associated course moodle.

Literature


Computational Social Science

Number of participants limited to 40.

Abstract

The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g., sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

Objective

Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.
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Literature

- Computational Social Science
  https://science.sciencemag.org/content/sci/323/5915/721.full.pdf
- Manifesto of Computational Social Science
  https://link.springer.com/article/10.1140/epjst/e2012-01697-8
- Social Self-Organisation
- How simple rules determine pedestrian behaviour and crowd disasters
  https://www.pnas.org/content/108/17/6884.short
- Peer review and competition in the Art Exhibition Game
  https://www.pnas.org/content/113/30/8414.short
- Generalized network dismantling
  https://www.pnas.org/content/116/14/6554.short
- Computational Social Science: Obstacles and Opportunities
  https://science.sciencemag.org/content/369/6507/1060?rss=1
- Bit by Bit: Social Research in the Digital Age
  https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFXX2/

Further literature will be recommended in the lectures.

Taught competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

851-0586-03L  Applied Network Science: Social Media Networks
Number of participant limited to 20

Abstract
We study applications of network science methods, this semester in the domain of social media. Topics are selected for diversity in research questions and techniques for topics such as privacy and information spread on a variety of platforms. Student teams present results from the recent literature, possibly with replication, in a one-day conference.

Objective
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on social media, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

851-0745-00L  Ethics Workshop: The Impact of Digital Life on Society
Number of participants limited to 40.

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice
- Work in a more ethically reflective way

Content
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, news media, society, social media, digital health and justice will be then considered. These six domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explain-ability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.
Advanced Topics in Evidence-Based Design for Architecture
Course requirements: Completion of the course Evidence-Based Design: Methods and Tools For Evaluating Architectural Design (851-0252-08L)

Abstract
Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.

Objective
Students will build on their previous projects as part of the course "Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University Designing the post-pandemic hospital with evidence. for people. The course is funded by an ETH innoedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

Complex Social Systems: Modeling Agents, Learning, and Games
Number of participants limited to 100.

Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract
This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective
The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

Content
Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lecture notes
The lecture slides will be presented on the course web page after each lecture.

Literature
Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

Prerequisites / notice
The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Analytical Competencies
Decision-making
Media and Digital Technologies

Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork

Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence

Sensitivity to Diversity

Personal Competencies
Negotiation
Adaptability and Flexibility

Critical Thinking
Integrity and Work Ethics

Self-awareness and Self-reflection
Self-direction and Self-management

From Traffic Modeling to Smart Cities and Digital Democracies
Number of participants limited to 40.
Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

Objective
To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

Literature
Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future
Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/9020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/886.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective-collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f48e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_1?dchild=1&keywords=coordination+Jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Further literature will be recommended in the lectures.
Taught competencies

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<td>Customer Orientation</td>
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<tr>
<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

851-0601-00L Participatory Resilience


Abstract
The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

Objective
The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

Content
The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems.

Prerequisites / notice

Please visit our website: https://participatoryresilience.ch/

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.

851-0252-07L Humans and Social Networks in the Digital Age

W 3 credits 2S C. Stadtfeld, T. Elmer

Abstract
The digital transformation profoundly impacts humans and how they behave online and offline. Interactions in online social networks offer new opportunities (e.g., political movements, communication) and risks (e.g., fake news, mental health risks). In this seminar, we examine sociological and psychological research on how the digital transformation affects individuals and their (social) behavior.

Objective
By the end of this seminar, students will be able to identify and compare different approaches in (online) social network research. They will be familiar with recent publications in the fields of social networks and computational social science and be able to critically participate in a number of open debates in these fields. Among others, these debates are centered around the types and measurement of social behavior in online and offline settings, ethical challenges in conducting social networks research, the effects of the digital transformation on people's feelings, thoughts, and behaviors (e.g., digital mental health), and how online social phenomena emerge (e.g., political movements).

Learning Objectives:
- Know the most relevant social network terminology and concept
- Know the most relevant sociological and psychological social network theories
- Know the most relevant methods to study online and offline behavior
- Be able to develop meaningful social networks research questions
- Be able to design your own social networks study
- Critically examine empirical research in the field of (online) social networks

Content
The digital transformation has made the “online world” increasingly important for the “offline world.” Hence, interactions in online social networks ultimately affect how people feel, think, behave and interact in offline settings. This course aims to present and structure open debates in online and offline social network research with a focus on social network processes, individual outcomes, and emergent phenomena. By taking a social networks perspective, we view individuals and their behavior in online and offline settings as part of a larger social environment and social phenomena as emerging from intertwined social behavior.

851-0345-00L A Seminar Cycle on Africa

W 3 credits 2V A. Mabanckou

Abstract
Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

Objective
This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe.
Content

In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called "littérature ‘nègre’", which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the “nègritude”, this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d’Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the ‘immigration novel’.

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbougar Sar, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of "ghettoization". African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of “Noirs en France”
On January 18, 2022, the documentary “Noirs en France” (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the “question of being black” still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary "Noirs en France".

NB: The names of the guests in the seminars might change.

### Science Research

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td>851-0020-00L</td>
<td>Gender and Science</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>N. El Kassar, C. L. Blaser</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This lecture series offers an introduction to the relationship between gender and science, with a focus on the specific intersections with the sciences taught at ETH.</td>
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<td><strong>Objective</strong></td>
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<td>This lecture series is designed to acquaint students from all levels and departments with the various ways in which gender perspectives matter for specific scientific disciplines, as well as for science in general. Students will learn to recognize and analyse the specific ways in which scientific theories and methods are gendered. They will be able to discuss and reflect how these topics are connected to their own scientific disciplines.</td>
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<td><strong>Content</strong></td>
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<td>There is agreement across academic disciplines today that gender influences and structures the production of knowledge and that scientific knowledge production in turn shapes gender notions. Even within “hard” sciences such as mathematics, physics, engineering, etc., gender is a significant factor in determining what counts as “objective” knowledge, who can know it, what kind of knowledge is produced, or how this knowledge is acquired and justified. Feminist research aims to reveal how dominant conceptions of science and knowledge practices disadvantage women&quot;, and other subordinate groups, with the goal of reforming these practices. An important part of feminist criticise is to show that such efforts substantially improve the overall quality of research.</td>
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<td>The semester will start with two introductory lectures acquainting students with research questions in the field of Gender and Science by summarizing its key concepts and methods. It will then continue as a series of weekly guest lectures by scholars from different scientific disciplines that provide accessible insights into the intersection between gender studies and the guest lecturer’s research field. Students will thereby be encouraged to learn from concrete examples rather than abstract theory. The goal is for students to understand how to apply concepts and methods of gender studies to their particular disciplines. Intermediate discussions with the students will provide a forum for critically reflecting the content of the lectures and the connections to their own academic fields and practices.</td>
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<td>All lectures by the guest speakers will also be open to the broader ETH public, while the introductory and discussion sessions are only for registered course participants.</td>
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<tr>
<th>851-0184-00L</th>
<th>Pluralist Philosophy of Mathematics</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>R. Wagner</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This course will follow Michèle Friend's book &quot;pluralism in mathematics&quot;. It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.</td>
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<td><strong>Objective</strong></td>
<td>The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.</td>
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The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our diagnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralist and paraconsistent philosophical approaches.

Subject-specific Competencies
- Concepts and Theories assessed
- Analytical Competencies assessed
- Critical Thinking assessed

Type B: Reflection About Subject-Specific Methods and Contents
Subject-specific courses. Particularly relevant for students interested in those subjects.

D-ARCH

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<tr>
<th>Number</th>
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<td>851-0703-00L</td>
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<td>W</td>
<td>2</td>
<td>2V</td>
<td>O. Streiff Gnöpff</td>
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<tr>
<td>851-0742-00L</td>
<td>Contract Design I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Stremitzer</td>
</tr>
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</table>

Further details can be found online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Objective
- Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

Content
- Basic concepts of law, sources of law.
- Private law: Contract law (particularly contract for work and services), tort law, property law.
- Public law: Human rights, administrative law, procurement law, procedural law.
- Insights into the law of the EU and into criminal law.

Lecturers
- Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Prerequisites
- Suitable for students of D-ARCH, D-MAVT, D-MATL

Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

Course Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Prerequisites
- Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@ethz.ehtz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).
<table>
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<tr>
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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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**851-0703-04L** Law and Urban Space  
*Particularly suitable for students of D-ARCH*

**Abstract**  
Legal rules are tied to urban space. Illustrative is the relation between land ownership and urban morphology or between zoning and the functional dimension of urban space. Legal concepts (from property law, fundamental rights and administrative law) with spatial impacts are introduced and related to the theory of urban design. Moreover, it is discussed how these concepts shape specific places.

**Objective**  
Students recognize the interplay between legal structures and urban space. They can describe legal concepts with spatial impact. Moreover, they are able to compare legally binding targets with theoretical approaches in urban design. By analysing specific places, students learn to find relevant norms, to analyse and to judge them with regard to urban design theories. Thereby, they are able to distinguish design and policy questions.

**Content**  
Using the the term «lawscape» (Philippopoulos-Mihalopoulos), we initially discuss general aspects of the interplay between legal rules and urban space.

The first part of the course is about the morphological dimension of urban space. We compare positions of urban planners like Trancik (Finding Lost Space) or Rowe/Koetter (Collage City) with property law. Freedom of property in turn contrasts to the theoretical approaches of Bernoulli (Die Stadt und ihr Boden) or Rossi (L’architettura della città). Using court decisions concerning nail houses, we study the tensions between urban development and the system of property ownership.

The second part of the course is about the functional dimension of urban space. Key concept is the zone (cf. CIAM 4). This concept is criticized (Wolfrum, Zonen Bien Défini). We compare the concept as well as the critique with the main concerns in spatial planning law. Environmental law and neighbours rights are also relevant.

In the third part of the course, we work on the social, visual and temporal dimensions of urban space. The positions of Jacobs (The Death and Life of Great American Cities), Cullen (Townscape) or Lynch (The Presence of the Past) are compared with the dichotomy public space/private space, safety regulations, regulations on design reviews or heritage protection laws.

Working tools are theoretical texts, legal rules, court decisions as well as site analyses. Students undertake a case study in small groups. Selected case studies are presented and discussed in a final meeting.

**Lecture notes**  
See Literature.

**Literature**  
Documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17513).

**Number of participants limited to: 45**

**851-0707-00L** Space Planning Law and Environment  
*Particularly suitable for students of D-ARCH, D-BAUG, D-USYS*

**Abstract**  
System of swiss planning law, Constitutional and statutory provisions, Space planning and fundamental rights, Instruments, Application, legal protection, enforcement, Practical training.

**Objective**  
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

**Content**  

**Lecture notes**  
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

**Number of participants limited to: 35**

**851-0252-01L** Human-Computer Interaction: Cognition and Usability  
*Particularly suitable for students of D-ARCH, D-INFK, D-ITET*

**Abstract**  
This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS).

The seminar will provide an opportunity to experience some of the methods in applied group projects.

**Objective**  
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

**851-0252-08L** Evidence-Based Design: Methods and Tools for Evaluating Architectural Design  
*Particularly suitable for students of D-ARCH*

**Number of participants limited to 40**
Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

<table>
<thead>
<tr>
<th>Course Code</th>
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<td>851-0724-01L</td>
<td>Real Estate Property Law</td>
<td>W</td>
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<td>Stefan Stucki, R. Müller-Wyss</td>
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<td>- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005</td>
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<td>- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.</td>
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<tr>
<td>851-0467-00L</td>
<td>From Traffic Modeling to Smart Cities and Digital Democracies</td>
<td>W</td>
<td>3 credits</td>
<td>D. Helbing, S. Mahajan</td>
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<td>Number of participants limited to 40.</td>
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<td>This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.</td>
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<td>To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.</td>
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<td>This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.</td>
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Further literature will be recommended in the lectures.
The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

Objective
The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

Content
We will start this seminar with a close reading of Paul Feyerabend Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang.html). It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Contract Design II
Does not take place this semester.
This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).
To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.
Abstract
Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a hypothetical client organization planning to enter a complex transaction on how to structure the underlying contract.
Objective
There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer’s Teaching Assistant Diego Caldera (diegoalberto.calderaherrera@uzh.ch).
Prerequisites / notice
To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

Advanced Topics in Evidence-Based Design for Architecture
Course requirements: Completion of the course Evidence-Based Design: Methods and Tools For Evaluating Architectural Design (851-0252-08L)
Abstract
Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.
Objective
Students will build on their previous projects as part of the course " Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University Designing the post-pandemic hospital with evidence. for people. The course is funded by an ETH innoventure project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

Participatory Resilience
The Participatory Resilience hackathon is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon’s central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.
We encourage students from different backgrounds and expertise to participate in this course.

Please visit our website: https://participatoryresilience.ch/
Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Objectives

- Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Prerequisites

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Problem-solving
- Personal Competencies: Critical Thinking

Lectures

- Handouts, prerecorded videos, slides, and other materials

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Prerequisites and Notice

Students must hand in an extensive group project in addition to the weekly quizzes and take-home questions. Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Number of participants limited to 160. Max 80 ETHZ and 80 UZH Students

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

The course will be held in a flipped classroom model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.
| Prerequisites / notice | Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch). |
| Taught competencies Subject-specific Competencies | Concepts and Theories assessed |
| | Techniques and Technologies assessed |
| | Analytical Competencies assessed |
| | Decision-making assessed |
| | Problem-solving assessed |
| | Communication assessed |
| | Cooperation and Teamwork assessed |
| | Customer Orientation assessed |
| | Negotiation assessed |
| | Creative Thinking assessed |
| Literature | Konrad Ott/Jan Dierks/Lieske Vogel-Klessich, Handbuch Umweltethik, 2016 |
| | John O'Neill et al., Environmental Values, 2008 |
| | Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003 |
| | O. Bucher |
| 701-0703-00L Environmental Ethics | W 2 credits 2V A. Deplazes Zemp |
| Abstract | The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges. |
| Objective | On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises. |
| Content | - Introduction to general and applied ethics. |
| | - Overview and discussion of ethical theories relevant to address environmental challenges. |
| | - Familiarisation with various basic standpoints within environmental ethics. |
| | - Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc. |
| | - Practicing of newly acquired knowledge in smaller exercises. |
| Lecture notes | Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists. |
| | - Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003 |
| | - Konrad Ott/Jan Dierks/Lieske Vogel-Klessich, Handbuch Umweltethik, 2016 |
| | - Marcus Düwell et. al., Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006 |
| | - John O'Neill et al., Environmental Values, 2008 |
| | -конрад Ott/Jan Dierks/Lieske Vogel-Klessich, Handbuch Umweltethik, 2016 |
| | General introductions: |
| | - Marcus Düwell et. al. (Hrsg.), Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006 |
| | - Johannes S. Ach et. al. (Hrsg.), Grundkurs Ethik 1. Grundlagen, Paderborn (mentis) 2008 |
| Prerequisites / notice | The procedure for accumulating CP will be explained at the start of term. |
| 052-0801-00L Global History of Urban Design I | W 2 credits 2G T. Avermaete |
| Abstract | This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances. |
| Objective | The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work. |
| Content | In the first semester the generation of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts: |
| | 01. The History and Theory of the City as Project |
| | 02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus |
| | 03: The Idea of the Polis: Rome, Greece and Beyond |
| | 04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi |
| | 05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles |
| | 06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization |
| | 07: The City of Labor: Company Towns as Cross-Cultural Phenomenon |
| | 08: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again |
| | 101: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham |
| | 101: The Expansion of the European City: From the Viennese Ringstrasse to Amsterdam Zuid |
Lecture notes: Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

Literature: There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

Prerequisites / notice: A list of further recommended literature will be found within each chapter of the reader (Skript).

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

851-0650-00L AI4Good 3 credits 2G J. D. Wegner

Abstract: The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective: Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too. The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Prerequisites / notice: Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0724-01L Real Estate Property Law 3 credits 3V S. Stucki, R. Müller-Wyss

Abstract: Particularly suitable for students of D-ARCH, D-BAUG, D-USYS

Objective: Overview of the legal norms of land registry and surveying law.

Content: Basic principles of material and formal land registry law, components of the land register, consequences of the land register, the registration process, legal problems of land surveying, reform of official surveying, liability of the geometer.

Lecture notes: Abgegebene Unterlagen: Skript in digitaler Form

- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

Taught competencies: Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

851-0742-01L Contract Design II 1 credit 1U A. Stremitzer

Does not take place this semester.

This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).
To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

Abstract
Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

Objective
There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer’s Teaching Assistant Diego Caldera (diego.calberto.calderaherrera@uzh.ch).

Prerequisites / notice
To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

851-0426-00L
Paul Feyerabend’s Anarchistic Theory of Knowledge

W 3 credits 2S M. Hagner, M. Hampe

Abstract
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Content
We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

D-BIOL

Number Title Type ECTS Hours Lecturers
851-0180-00L Research Ethics W 2 credits 2G G. Achermann, P. Emch

Number of participants limited to 40

Abstract
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective
Participants of the course Research Ethics will

• Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;

• Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

Content
I. Introduction to Moral Reasoning 1. Ethics - the basics 1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics 2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma 3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities 1. Integrity in research and research misconduct 1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management 2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing 3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities 1. Research involving human subjects 1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility 2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research 3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 2295 of 2345
This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus on the modern life sciences since the 19th century. The course will combine both an overview of major areas of law that are relevant for the regulation of particularly on the challenges to current law posed by prominent near-future technologies.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

The course Slack workspace. Information about the assignment and for access to the instructors via email (lawtech@gess.ethz.ch) for within two weeks of registering. Please contact the Polybox: https://polybox.ethz.ch/index.php/s/o7dttHXV5jAl9CE

Prerequisites / notice

What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...).

Taught competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving

Social Competencies
Communication

Personal Competencies
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection

Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

Taught competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Problem-solving

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection

Prerequisites / notice

Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/s/o7dtHv5Ja9I9CE) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

Abstract

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content

The planned course outline is below:
1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

851-0732-06L
Law & Tech
W 3 credits
K. Houshang Pour Islam

851-0157-28L
Life and Death
W 3 credits
M. Hagner

851-0738-01L
The Role of Intellectual Property in the Engineering and Technical Sector
W 2 credits
K. Houshang Pour Islam

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

Taught competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Problem-solving

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection

Prerequisites / notice

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content

The planned course outline is below:
1. Overview of law and technology
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- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content

The planned course outline is below:
1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

851-0732-06L
Law & Tech
W 3 credits
A. Stremitzer, J. Merane, A. Nielsen

851-0157-28L
Life and Death
W 3 credits
M. Hagner

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.
Objective
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and mortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and the natural realities of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0426-00L

Paul Feyerabend's Anarchistic Theory of Knowledge

W 3 credits

Objective
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time. We will start this seminar with a close reading of Paul Feyerabend's magnum opus "Wider den Methodenzwang" (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783512851970/) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend's other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

Abstract
Paul K. Feyerabend characterized his magnum opus "Against method" as an "anarchistic theory of knowledge". In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend's advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Content
The course will be based on selected chapters and sections from Feyerabend's monographs and will cover the following topics:

1. Anarchistic science: The case for multiple forms of knowledge.
2. The methodology of science: How to avoid methodological prejudice.
3. The relationship between science and society: How science is shaped by social and political forces.
4. The role of experts: How to avoid the expert trap.
5. The role of ideology: How ideology shapes scientific knowledge.
6. The role of politics: How politics shapes scientific knowledge.
7. The role of power: How power shapes scientific knowledge.
8. The role of authority: How authority shapes scientific knowledge.
9. The role of history: How history shapes scientific knowledge.
10. The role of culture: How culture shapes scientific knowledge.
11. The role of language: How language shapes scientific knowledge.
12. The role of values: How values shape scientific knowledge.
13. The role of emotions: How emotions shape scientific knowledge.
14. The role of imagination: How imagination shapes scientific knowledge.
15. The role of intuition: How intuition shapes scientific knowledge.
16. The role of creativity: How creativity shapes scientific knowledge.
17. The role of invention: How invention shapes scientific knowledge.
18. The role of discovery: How discovery shapes scientific knowledge.
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Prerequisites / notice
This course is particularly suitable for students of D-BAUG, D-BIOL, D-BSSE, D-CHAB, D-ITET, D-MAVT.

851-0738-01L

The Role of Intellectual Property in the Engineering and Technical Sector

W 2 credits

Objective
The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

Prerequisites / notice
The lecture addresses students in the fields of engineering, science and other related technical fields.

Taught competencies

- Subject-specific Competencies
  - Concepts and Theories
    - Assessed
- Method-specific Competencies
  - Problem-solving
    - Assessed
- Personal Competencies
  - Critical Thinking
    - Assessed
  - Self-awareness and Self-reflection
    - Assessed

Data: 18.08.2022 12:39
Autumn Semester 2022
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It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time. We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

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<tr>
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<tr>
<td>851-0180-00L</td>
<td>Research Ethics</td>
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**Objective**

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

**Content**

We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.
This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Contract Design I (851-0742-00L; Fall 2022)" and enroll. The password is "ContractDesign01".

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Abstract

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Objective

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Lecture notes

Handouts, prerecorded videos, slides, and other materials

Prerequisites / notice

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Taught competencies

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<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>851-0738-00L Intellectual Property: Introduction</td>
<td>2 credits</td>
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</table>
Objective

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector

ECTS 2V

W 2 credits 2V K. Houshang Pour Islam

Abstract

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Objective

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the protecting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

851-0742-01L Contract Design II

W 1 credit 1U A. Stremitzer

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

Abstract

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

Objective

There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer’s Teaching Assistant Diego Caldera (diegoalberto.caldarerrera@uzh.ch).

Prerequisites / notice

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

851-0157-28L Life and Death

W 3 credits 2V M. Hagner

Life and Death

Particularly suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS

Abstract

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Objective

The course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time. We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

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Environmental Ethics

**W 2 credits 2V A. Deplazes Zemp**

**Abstract**
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

**Objective**
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

**Content**
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

**Lecture notes**
Presentation slides of individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

**Literature**
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O’Neill et al., Environmental Values, 2008
- Konrad Ott/Jan Diers/ Liese Vogt-Klessin, Handbuch Umweltethik, 2016

**Prerequisites / notice**
The procedure for accumulating CP will be explained at the start of term.
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

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The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

**Objective**
- Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

**Content**
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

**Prerequisites / notice**
- Note: The course AI4Good is not related to Hack4Good, which is a students’ initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.
- Students with a strong background in machine learning and excellent programming skills (preferably in Python)

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**Paul Feyerabend’s Anarchistic Theory of Knowledge**

**W 3 credits 2G J. D. Wegner**

**Abstract**
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

**Objective**
- It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.
- We know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

**Content**
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

**Literature**
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O’Neill et al., Environmental Values, 2008
- Konrad Ott/Jan Diers/ Liese Vogt-Klessin, Handbuch Umweltethik, 2016

**Prerequisites / notice**
The procedure for accumulating CP will be explained at the start of term.
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.
I. Introduction to Moral Reasoning

1. Ethics - the basics
   1.1 What ethics is not…
   1.2 Recognising an ethical issue (awareness)
   1.3 What is ethics? Personal, cultural and ethical values, principles and norms
   1.4 Ethics: a classification
   1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
   2.1 What is normative ethics?
   2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories
   2.3 The plurality of normative theories (moral pluralism);
   2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
   3.1 How (not) to approach ethical issues
   3.2 What is a moral dilemma? Is there a correct method for answering moral questions?
   3.3 Methods of making ethical decisions

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
   1.1 What is research integrity and why is it important?
   1.2 What is research misconduct?
   1.3 Questionable/Detrimental Research Practice (QRDWRP)
   1.4 What is the incidence of misconduct?
   1.5 What are the factors that lead to misconduct?
   1.6 Responding to research wrongdoing
   1.7 The process of dealing with misconduct
   1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
   2.1 Data collection and recordkeeping
   2.2 Analysis and selection of data
   2.3 The (mis)representation of data
   2.4 Ownership of data
   2.5 Retention of data
   2.6 Sharing of data (open research data)
   2.7 The ethics of big data

3. Publication ethics / Responsible publishing
   3.1 Background
   3.2 Criteria for being an author
   3.3 Ordering of authors
   3.4 Publication practices

III. Research Ethics – External responsibilities

1. Research involving human subjects
   1.1 History of research with human subjects
   1.2 Basic ethical principles – The Belmont Report
   1.3 Requirements to make clinical research ethical
   1.4 Social value and scientific validity
   1.5 Selection of study participants – the concept of vulnerability
   1.6 Favourable risk-benefit ratio
   1.7 Independent review - Ethics Committees
   1.8 Informed consent
   1.9 Respect for potential and enrolled participants

2. Social responsibility
   2.1 What is social responsibility?
   2.2 Participation in public discussions
   2.3 Public advocacy (policy making)

3. Dual use research
   3.1 Introduction to Dual use research
   3.2 Case study – Censuring science?
   3.3 Transmission studies for avian flu (H5N1)
   3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!),
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Taught competencies

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Ethics Workshop: The Impact of Digital Life on Society

W 2 credits 2S

E. Vayena, A. Blasimme, A. Ferretti, C. Landers, J. Sleigh

Number of participants limited to 40.

Open to all Master level / PhD students.

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective
Explain relevant concepts in ethics.
Evaluate the ethical dimensions of new technology uses.
Identify impacted stakeholders and who is ethically responsible.
Engage constructively in the public discourse relating to new technology impacts.
Review tools and resources currently available that facilitate resolutions and ethical practice.
Work in a more ethically reflective way.
### E. Valdameri

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective. While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

### H. Zhao

The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory

### J. Argota Sánchez

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, news media, society, social media, digital health and justice will be then considered. These six domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explain-ability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

### 851-0157-28L

**Life and Death**

*Particularly suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS*

**Abstract**

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

**Objective**

There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immunity have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

### 851-0426-00L

**Paul Feyerabend's Anarchistic Theory of Knowledge**

**Abstract**

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**Objective**

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

**Content**

We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

### 851-0011-00L

**The Body in Global History**

**Abstract**

While being the universal constant which is common to every human being in history, the body is also culturally and historically specific. In this seminar we will examine how ideas of the body have changed throughout history and how these ideas of the body can be useful to understand political, social, and cultural phenomena in particular historical settings.

**Objective**

Students learn the history of the body from mid-eighteenth century onwards through examples taken from the multidisciplinary scholarship on the body with a special, albeit not exclusive, focus on colonial and postcolonial contexts. More specifically, students are sensitized to the historical and cultural variabilities of the human body that challenge scientific understandings of it as an unchanging biological entity.

**Content**

Adopting a humanities perspective on topics like anatomy and surgery, the treatment of the insane, sexuality, physical culture, eugenics, and body productivity, the course looks at shifting attitudes to body health and fitness and the ways these have been shaped by considerations of gender, race, and class as well as by socioeconomic circumstances of modernity. It considers how bodies have historically concerned governments who have classified different (sections of) populations as ‘fit or unfit’ to be members of a certain community.

The ‘long durée’ approach of the course allows to consider the continuities and changes in terms of scientific epistemologies and practices regarding the body. In doing so, debated contemporary issues such as assisted reproductive technologies and wearable systems of surveillance of the worker fatigue in the workplace are discussed.

The course is structured thematically, adopts a multidisciplinary approach, and uses academic texts as well as concrete examples. It intends to a) enable STEM students to develop new perspectives on their core subjects by bringing them in dialogue with the themes dealt with and by raising ethical questions; b) familiarise students in general with major topics in the field of the recent scholarship on the body and make them mindful of the multiple ways in which understanding the body and its relationship with culture and power can help think critically of the present we live in.

### 851-0601-00L

**Participatory Resilience**

**Abstract**

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

**Objective**

The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

**Content**

The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

Please visit our website: https://participatoryresilience.ch/

**Prerequisites / notice**

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.

**Number**

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0252-01L</td>
<td>Human-Computer Interaction: Cognition and Usability</td>
<td>W</td>
<td>3</td>
<td>2S</td>
</tr>
</tbody>
</table>
The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.

### E-Business-Law

**Course Code:** 851-0727-02L  
**Title:** E-Business-Law  
**Credit Hours:** 2  
**Prerequisites:** Particularly suitable for students of D-INFK, D-ITET  

The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.
The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, and which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

Addendum

The following topics will be covered:

1) Which are the legal rules governing e-Business?
   - International law
   - Regulation of branches

2) Marketing of E-Business Offerings
   - Use of foreign and protection of own data
   - Marketing in E-Business (in a certain extent)
   - Use of Domain Names

3) Relationship to E-Business Customers
   - Sales in E-Business, Consumer Protection
   - Electronic Signatures
   - Data Protection
   - Spam

4) Sales with E-Business Providers

Changes, statements, and extensions are reserved. The course plan for the current term and topic plan is available at the time of publication.

Notes

The course will be taught in slides, which are available as PDFs via the electronic repository (ILIAS) on the ETHZ system beforehand.

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thievery).

851-0738-00L Intellectual Property: Introduction

Particularly suitable for students of D-CHAB, D-INFK, D-ITET, D-MAVT, D-MATL, D-MTEC

Abstract

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

Objective

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

851-0252-13L Network Modeling

Particularly suitable for students of D-INFK and in the MSc Data Science

Abstract

Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective

Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and tests those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and develop an understanding of how these can be fit to empirical data. This will enable students to independently address research questions from various social science fields.

Content

The following topics will be covered:

- Introduction to network models and their applications
  - Stylized models:
    * uniform random graph models
    * small world models
    * preferential attachment models
  - Models for testing hypotheses while controlling for the network structure:
    * Quadratic assignment procedure regression (QAP regression)
  - Models for testing hypotheses on the network structure:
    * Models for one single observation of a network: exponential random graph models (ERGMs)
    * Models for panel network data: stochastic actor-oriented models (SAOMs)
    * Models for relational event data: dynamic network actor models (DynAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes

Slides and lecture notes are distributed via the associated course moodle.
The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability and application.

The planned course outline is below:

### Network Analysis

- **Abstract**: Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

- **Objective**: Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

- **Content**: The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:
  - Empirical Research and Network Data
  - Macro and Micro Structure
  - Centrality
  - Roles
  - Cohesion

- **Lecture notes**: Lecture notes are distributed via the associated course moodle.

- **Literature**

- **851-0252-15L**
  - **Network Analysis**
  - **Prerequisites**: Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.
  - **Objective**: Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.
  - **Content**: The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:
    - Empirical Research and Network Data
    - Macro and Micro Structure
    - Centrality
    - Roles
    - Cohesion
  - **Lecture notes**: Lecture notes are distributed via the associated course moodle.
  - **Literature**

- **851-0732-06L**
  - **Law & Tech**
  - **Objective**: This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.
  - **Content**: The planned course outline is below
    - 1. Overview of law and technology
    - 2. Digital Platforms
    - 3. AI Fairness
    - 4. Consumer Bots and Consumer Protection
    - 5. Drones
    - 6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
    - 7. Law and Tech scholarship series
  - **Prerequisites**: Basic programming skills, elementary probability and statistics.
  - **Objective**: This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis.
  - **Lecture notes**: The lecture slides will be presented on the course web page after each lecture.

- **851-0101-86L**
  - **Complex Social Systems: Modeling Agents, Learning, and Games**
  - **Objective**: Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.
  - **Prerequisites**: Basic programming skills, elementary probability and statistics.
  - **Objective**: This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis.
  - **Lecture notes**: The lecture slides will be presented on the course web page after each lecture.
Literature

Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

Prerequisites / notice

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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<td></td>
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<tr>
<td>Method-specific Competencies</td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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</tr>
<tr>
<td></td>
<td>Customer Orientation</td>
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<tr>
<td></td>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td>Sensitivity to Diversity</td>
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<td></td>
<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptable and Flexibility</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

851-0760-00L Building a Robot Judge: Data Science for Decision-Making
Particularly suitable for students of D-INFK, D-ITET, D-MTEC

W 3 credits 2V E. Ash

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

851-0761-00L Building a Robot Judge: Data Science for Decision-Making (Course Project)
This is the optional course project for "Building a Robot Judge: Data Science for the Law."

W 2 credits 2V E. Ash

Please register only if attending the lecture course or with consent of the instructor.

Some programming experience in Python is required, and some experience with text mining is highly recommended.

Abstract
Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

Objective
In a semester paper, students (individually or in groups) will conceive and implement their own research project applying natural language tools to legal texts. Some programming experience in Python is required, and some experience with NLP is highly recommended.
Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural network models. We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.

851-0650-00L  AI4Good  W  3 credits  2G  J. D. Wegner

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0467-00L  From Traffic Modeling to Smart Cities and Digital Democracies  W  3 credits  2S  D. Helbing, S. Mahajan

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

Objective
To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Literature

Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future

Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/2020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/686.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f48e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_fkmr1_1?dchild=1&keywords=coordination+Jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Decentralized Collective Learning for Self-managed Sharing Economies
https://dl.acm.org/doi/abs/10.1145/3277688

Further literature will be recommended in the lectures.
The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a
pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach
to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general
merits and limitations of pluralist and paraconsistent philosophical approaches.

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using
an interdisciplinary jury on the last day.

Please visit our website: https://participatoryresilience.ch/

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data
analysis.

Paul Feyerabend's Anarchistic Theory of Knowledge

Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded
against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been
debated heatedly, but is still relevant for contextualizing the role of science in society.

The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about
mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using
open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas,
discuss best practices, and build innovative open-source solutions that promote participation and resilience.

The course will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental
and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of
Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are
suitable for the hackathon’s central theme. The students will organize themselves into teams of 3–5 students, where each group works on
solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to
an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data
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resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems.

Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental
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an interdisciplinary jury on the last day.

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It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data
analysis.

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using
an interdisciplinary jury on the last day.

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an interdisciplinary jury on the last day.

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It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data
analysis.
The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.

Objective
The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

Content
Vorgesehene Strukturierung der Vorlesung:
1) Welches Recht gilt im E-Business?
   - Internationalität des Internets
   - Regulierter Branchen

2) Gestaltung und Vermarktung von E-Business-Angeboten
   - Verwendung fremder und Schutz der eigenen Inhalte
   - Haftung im E-Business (und wie sie beschränkt werden kann)
   - Domain-Namen

3) Beziehung zu E-Business-Kunden
   - Verträge im E-Business, Konsumentenschutz
   - Elektronische Signaturen
   - Datenschutz
   - Spam

4) Verträge mit E-Business-Providern

Änderungen, Umstellungen und Kürzungen bleiben vorbehalten. Der aktuelle Termin- und Themenplan ist zu gegebener Zeit über die elektronische Dokumentenablage abrufbar.

Lecture notes
Es wird mit Folien gearbeitet, die als PDF über die elektronische Dokumentenablage (ILIAS) auf dem System der ETHZ vorgängig abrufbar sind. Der Termin- und Themenplan (ebenfalls online abrufbar) sind Links zu Gesetzentexten und weiteren Unterlagen abrufbar. Schliesslich wird jede Vorlesung auch als Podcast aufgezeichnet, der jedoch nur für die Studierenden mit einem Passwort (erhältlich beim Dozenten) zugänglich sind.

Literature
Weiterführende Materialien, Links und Literatur sind auf dem Termin- und Themenplan aufgeführt (zu gegebener Zeit abrufbar via elektronische Dokumentenablage).

Prerequisites / notice
Die Semesterendprüfung war Corona in Form eines schriftlichen Kurztests (normalerweise ein MC, im letzten Jahr Coronabedingt aber eine Falllösung) in der letzten Doppelstunde ausgestaltet. Es wird angegeben, welche Unterlagen beim jeweiligen Thema den Prüfungsstoff definieren. Der Test wird möglicherweise elektronisch durchgeführt.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Prerequisites / notice
This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

851-0727-02L E-Business-Law

Particularly suitable for students of D-INFK, D-ITET

Abstract
The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.

Objective
The course deals with key legal concepts relevant for doing e-business, in particular understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

Content
ABE - Part 1. The role of the law in the practical implementation and operation of e-business applications.

851-0725-01L Human-Computer Interaction: Cognition and Usability

Particularly suitable for students of D-ARCH, D-INFK, D-ITET

Abstract
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction scenario (e.g., an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

851-0735-10L Law for Entrepreneurs

Number of participants limited to 100

Abstract
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction scenario (e.g., an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

851-0727-02L E-Business-Law

Particularly suitable for students of D-INFK, D-ITET

Abstract
The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.

Objective
The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

Content
Vorgesehene Strukturierung der Vorlesung:
1) Welches Recht gilt im E-Business?
   - Internationalität des Internets
   - Regulierter Branchen

2) Gestaltung und Vermarktung von E-Business-Angeboten
   - Verwendung fremder und Schutz der eigenen Inhalte
   - Haftung im E-Business (und wie sie beschränkt werden kann)
   - Domain-Namen

3) Beziehung zu E-Business-Kunden
   - Verträge im E-Business, Konsumentenschutz
   - Elektronische Signaturen
   - Datenschutz
   - Spam

4) Verträge mit E-Business-Providern

Änderungen, Umstellungen und Kürzungen bleiben vorbehalten. Der aktuelle Termin- und Themenplan ist zu gegebener Zeit über die elektronische Dokumentenablage abrufbar.

Lecture notes
Es wird mit Folien gearbeitet, die als PDF über die elektronische Dokumentenablage (ILIAS) auf dem System der ETHZ vorgängig abrufbar sind. Der Termin- und Themenplan (ebenfalls online abrufbar) sind Links zu Gesetzentexten und weiteren Unterlagen abrufbar. Schliesslich wird jede Vorlesung auch als Podcast aufgezeichnet, der jedoch nur für die Studierenden mit einem Passwort (erhältlich beim Dozenten) zugänglich sind.

Literature
Weiterführende Materialien, Links und Literatur sind auf dem Termin- und Themenplan aufgeführt (zu gegebener Zeit abrufbar via elektronische Dokumentenablage).

Prerequisites / notice
Die Semesterendprüfung war Corona in Form eines schriftlichen Kurztests (normalerweise ein MC, im letzten Jahr Coronabedingt aber eine Falllösung) in der letzten Doppelstunde ausgestaltet. Es wird angegeben, welche Unterlagen beim jeweiligen Thema den Prüfungsstoff definieren. Der Test wird möglicherweise elektronisch durchgeführt.

851-0725-01L Human-Computer Interaction: Cognition and Usability

Particularly suitable for students of D-ARCH, D-INFK, D-ITET

Abstract
This seminar will introduce key topics, theories and methodology in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.

Objective
This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.

Number of participants limited to 35.
This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. The students should be able to implement simulation models and document their skills through a seminar thesis and a short oral presentation.

Particularly suitable for students of D-ITET, D-MAVT

Abstract
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective
The students shall obtain the following competences:
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be familiar with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be aware of the issues of corporate compliance, i.e., the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.

Lecture notes
A comprehensive script will be made available online on the moodle platform.

The Role of Intellectual Property in the Engineering and Technical Sector

851-0738-01L

The lecture addresses students in the fields of engineering, science and other related technical fields.

Prerequisites / Notions
The lecture addresses students in the fields of engineering, science and other related technical fields.

Taught Competencies
The students shall obtain the following competences:
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be familiar with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be aware of the issues of corporate compliance, i.e., the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.

Lecture notes
A comprehensive script will be made available online on the moodle platform.

The lecture addresses students in the fields of engineering, science and other related technical fields.

Prerequisites / Notions
The lecture addresses students in the fields of engineering, science and other related technical fields.

Taught Competencies
The students shall obtain the following competences:
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.
- They shall be familiar with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be aware of the issues of corporate compliance, i.e., the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.

Lecture notes
A comprehensive script will be made available online on the moodle platform.
Literature
Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

Prerequisites / notice
The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Taught competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
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<td>Adaptability and Flexibility</td>
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<td>Analytical Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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851-0760-00L Building a Robot Judge: Data Science for Decision-Making

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

851-0761-00L Building a Robot Judge: Data Science for Decision-Making (Course Project)

Abstract
This is the optional course project for "Building a Robot Judge: Data Science for the Law."

Please register only if attending the lecture course or with consent of the instructor.

Some programming experience in Python is required, and some experience with text mining is highly recommended.

Objective
Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

In a semester paper, students (individually or in groups) will conceive and implement their own research project applying natural language tools to legal texts. Some programming experience in Python is required, and some experience with NLP is highly recommended.
Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.

851-0650-00L  AI4Good  W  3 credits  2G  J. D. Wegner

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0467-00L  From Traffic Modeling to Smart Cities and Digital Democracies  W  3 credits  2S  D. Helbing, S. Mahajan

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

Objective
To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Further literature will be recommended in the lectures.
Paul Feyerabend's Anarchistic Theory of Knowledge

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Introduction to Cognitive Science

Cognitive Science views human cognition as information processing and provides an inter-disciplinary integration of approaches from cognitive psychology, informatics (e.g., artificial intelligence), neuroscience and anthropology among others. The lectures provide an overview of basic mechanisms of human information processing and various application domains. A focus will be on matters of knowledge acquisition, representation and usage in information processing tasks.

Participatory Resilience

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

Law & Tech

Any students enrolling in the course must complete a short writing assignment within two weeks of registering. Please contact the instructors via email (lawtech@geiss.ethz.ch) for information about the assignment and for access to the course Slack workspace.

The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day. We encourage students from different backgrounds and expertise to participate in this course.

Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day. We encourage students from different backgrounds and expertise to participate in this course.

Prerequisites

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.

Course Date:

Autumn Semester 2022

Course Codes:

851-0426-00L

851-0252-02L

851-0601-00L

851-0732-06L

Data: 18.08.2022 12:39

Autumn Semester 2022

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The planned course outline is below

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

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<thead>
<tr>
<th>Number</th>
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<td>851-0742-00L</td>
<td>Contract Design I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Stremitzer</td>
</tr>
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</table>

This course is taught by Professor Alexander Stremitzer ([https://laweconbusiness.ethz.ch/group/professor/stremitzer.html](https://laweconbusiness.ethz.ch/group/professor/stremitzer.html)). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Handouts, prerecorded videos, slides, and other materials can be found on Moodle. You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Particularly suitable for students of D-INFK, D-MATH

Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.
The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

- Empirical Research and Network Data
- Macro and Micro Structure
- Centrality
- Roles
- Cohesion

**Lecture notes**
Lecture notes are distributed via the associated course moodle.

**Literature**

### 853-0061-00L Introduction to Cybersecurity Politics

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>M. Dunn Cavelti, F. J. Egloff</th>
</tr>
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</table>

**Abstract**
The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

**Objective**
Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.

**Content**
We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

**Lecture notes**
A script with background information and comments on the literature will be made available at the beginning of the semester.

**Literature**
Literature for each session will be available on Moodle.

**Prerequisites / notice**
The lecture is being supported by a website on Moodle.

### 853-8002-00L The Role of Technology in National and International Security Policy

<table>
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<tr>
<th>W</th>
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<th>A. Wenger, A. Dossi, M. Leese, O. Thränert</th>
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**Abstract**
The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

**Objective**
Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

**Content**

**Literature**
Literatur für die einzelnen Sitzungen wird auf Moodle bereitgestellt.

**Prerequisites / notice**
The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos, oliver.roos@isipo.gess.ethz.ch.

### 851-0650-00L AI4Good

<table>
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**Abstract**
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

**Objective**
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

**Content**
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning.

Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

**Prerequisites / notice**
Students with a strong background in machine learning and excellent programming skills (preferably in Python)
Introduction to Law

Students who have attended or will attend the lecture "Introduction to Law for Civil Engineering and Architecture" (851-0184-03L) or "Introduction to Law" (851-0708-00L), cannot register for this course unit.

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

Basic concepts of law, sources of law.

Private law: Contract law (particularly contract for work and services), tort law, property law.

Public law: Human rights, administrative law, procurement law, procedural law.

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

Intellectual Property: Introduction

Particularly suitable for students of D-ARCH, D-MAVT, D-MATL, D-MTEC

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.
Objective

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thicket).

853-0047-01L World Politics Since 1945: The History of International Relations (Without Exercises) 3 credits 2V A. Wenger

Abstract

This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.

Objective

By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.

Content

cf. “Diploma Supplement”

Prerequisites / notice

The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver roos (oliver.roos@sipo.gess.ethz.ch).

Taught competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: not assessed

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: not assessed
  - Project Management: not assessed

- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- Personal Competencies
  - Adaptability and Flexibility: assessed
  - Creative Thinking: not assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: assessed

701-0703-00L Environmental Ethics

W 2 credits 2V A. Deplazes Zemp

Abstract

The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective

On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Content

- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Lecture notes

Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

Literature

- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O’Neill et al., Environmental Values, 2008

Prerequisites / notice

The procedure for accumulating CP will be explained at the start of term.

853-0061-00L Introduction to Cybersecurity Politics

W 3 credits 2G M. Dunn Cavelti, F. J. Egloff

Abstract

The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

Objective

Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.

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Lecture notes

A script with background information and comments on the literature will be made available at the beginning of the semester.

Literature

A script with background information and comments on the literature will be made available at the beginning of the semester.
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will select problems based on the presentation and discussion of stakeholders. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members.

Objective

Students with a strong background in machine learning and excellent programming skills (preferably in Python) are expected. Information about Hack4Good can be found at https://analytics-club.org/wordpress/hack4good/. Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/. Students with a strong background in machine learning and excellent programming skills (preferably in Python) are expected. Information about Hack4Good can be found at https://analytics-club.org/wordpress/hack4good/. Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice

The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos, oliver.roos@ipio.gess.ethz.ch.

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853-8002-00L

The Role of Technology in National and International Security Policy

W 3 credits 2G

A. Wenger, A. Dossi, M. Leese, O. Thränert

Abstract

The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

Objective

Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

Content

The first part is dedicated to the security and military technologies. The second part deals with the questions of international and security policies. The third part focuses on the challenges of implementation and implementation and of the global context in which technology is being developed. The content of the last part will be adjusted to the needs and interests of the audience.

Literature

Literatur für die einzelnen Sitzungen wird auf Moodle bereitgestellt.

851-0650-00L

AI4Good

W 3 credits 2G

J. D. Wegner

Abstract

The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

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Prerequisites / notice

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851-0426-00L

Paul Feyerabend’s Anarchistic Theory of Knowledge

W 3 credits 2S

M. Hagner, M. Hampe

Abstract

Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Content

We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

D-MTEC

Number Title Type ECTS Hours Lecturers

851-0252-10L Project in Behavioural Finance W 3 credits 2S

S. Andraszewicz, C. Hölscher, A. C. Roberts

Abstract

In this seminar, students will study cognitive processes, behaviour and the underlying biological response to financial decisions. Research methods such as asset market experiments, lottery games, risk preference assessment, psychometrics, neuroimaging and psychophysiology of decision processes will be discussed. Financial bubbles and crashes will be the core interest.

Objective

This course has four main goals:

1) To learn about the most important topics within Behavioural Finance
2) To learn how to conduct behavioural studies, design experiments, plan data collection and experimental tasks
3) To learn about causes of market crashes, factors that influence them, traders’ behaviour before, during and after financial crises
4) To investigate a topic of interest, related to behaviour of traders during market crashes.

Additionally, the course gives to the students the opportunity to practice oral presentations, communication skills, report writing and critical thinking.

Data: 18.08.2022 12:39 Autumn Semester 2022 Page 2321 of 2345
The course provides an overview of the most important topics in Behavioural Finance. First part of the course involves reading scientific articles, which will be discussed during the seminar. Therefore, attendance is required to pass the course. Each week, a student volunteer will present a paper and the presentation will be followed by a discussion. After obtaining sufficient knowledge of the field, students will select a topic for a behavioural study of their own. The final assignment consists of preparing and conducting a small behavioural study/experiment, analysing the data and presenting the project in the final meeting of the class. Each student will write a scientific report of their study.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

The set-up of the course will closely follow the book of M. Schweizer. In parallel, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

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Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

### Taught competencies

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<tbody>
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### Objective

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.
Content
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
The book can also be used for the course "Principles of Macroeconomics" (Sturm)

For students taking only the course "Principles of Microeconomics" there is a shorter version of the same book:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

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<td>Self-direction and Self-management</td>
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351-1109-00L Introduction to Microeconomics

W: 3 credits
G: M. Wörter, M. Beck

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php


Prerequisites / notice
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.
This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Handouts, prerecorded videos, slides, and other materials

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Abstract

Objective

Lecture notes

Prerequisites / notice

Taught competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving not assessed

Social Competencies

Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Negotiation not assessed

Personal Competencies

Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Creative Thinking assessed

ETH students: Your grade will consist of two parts:
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2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

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Abstract

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We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
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Handouts, prerecorded videos, slides, and other materials

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).
Building a Robot Judge: Data Science for Decision-Making

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

851-0650-00L AI4Good

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the model.

Content
In a semester paper, students (individually or in groups) will conceive and implement their own research project applying natural language tools to legal texts. Some programming experience in Python is required, and some experience with NLP is highly recommended.

851-0742-01L Contract Design II

Abstract
Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

Objective
This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html). To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

851-0426-00L Paul Feyerabend's Anarchistic Theory of Knowledge

Abstract
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.
We will start this seminar with a close reading of Paul Feyerabend's *Wider den Methodenzwang* ([https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970](https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970)) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend's other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

### 851-0093-00L  Ethical Issues in the Economy

**Abstract**

Ecological crises and growing social inequalities rise the urgent question: Is the global way we are doing economics reasonable? – Which kind of wealth is illegitimate? Is a policy of de-growth needed for protecting our ecological niche? Will technological devices e.g. AI-driven market designs for public goods be the solution or is a change of attitudes necessary to cope with such problems?

**Objective**

Participants should learn to understand and being enabled to evaluate answers to the following questions:

1. To which extent are economic success and wealth something deserved, and to which extent are they the outcome of lucky circumstances or favorable conditions? And what follows from the answer for the judgment on social inequalities?
2. How much consumption and growth are enough?
3. Which commons should not be privatized?
4. What should entrepreneurs and consumers be responsible for?
5. Does a sharing economy promote a responsible way of doing business?
6. Are technologies for regulating production and allocation of resources as well as regulating consumptions of goods apt to cope with problems of social inequality, of protecting our ecological niche, and do they empower producers, investors and consumers to act responsible?
7. What are the good things and what are the bad things about the global capitalist scheme doing business in the 21st century?
8. Do we need a de-globalization of doing economics?

### 851-0601-00L  Participatory Resilience

**Abstract**

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

**Objective**

The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

### 851-0732-05L  Law & Tech

**Abstract**

Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/s/o7tdthXV5jaI9CE) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

**Objective**

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Content

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

The planned course outline is below

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

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### D-MAVT

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0742-00L</td>
<td>Contract Design I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Stremitzer</td>
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</table>

This course is taught by Professor Alexander Stremitzer ([https://lawebusiness.ethz.ch/group/professor/stremitzer](https://lawebusiness.ethz.ch/group/professor/stremitzer)). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent [here](https://participatoryresilience.ch/).
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. Both in production and technical inventions and the use of patent information.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Lecture notes
Handouts, prerecorded videos, slides, and other materials

Prerequisites / notice
Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INAFF, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Taught competencies

<table>
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<tr>
<th>Competency</th>
<th>Concepts and Theories</th>
<th>Assessed</th>
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<td>Techniques and Technologies</td>
<td>Assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>Assessed</td>
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<td>Creative Thinking</td>
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Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

The seminar will illustrate and deepen the topics addressed during the lecture.

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.
Objective

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

851-0735-00L

Law for Entrepreneurs

Number of participants limited to 100

Particularly suitable for students of D-ITET, D-MAVT

Abstract

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Objective

The students shall obtain the following competences:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes

A comprehensive script will be made available online on the moodle platform.

851-0703-00L

Introduction to Law

Students who have attended or will attend the lecture "Introduction to Law for Civil Engineering and Architecture" (851-0703-03L) or "Introduction to Law" (851-0708-00L), cannot register for this course unit.

Particularly suitable for students of D-ARCH, D-MAVT, D-MATL

Abstract

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Objective

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

Content

Basic concepts of law, sources of law.
Private law: Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.
Insights into the law of the EU and into criminal law.

Lecture notes

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Literature

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

853-0047-01L

World Politics Since 1945: The History of International Relations (Without Exercises)

Abstract

This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.

Objective

By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.

Content

cf. "Diploma Supplement"

Prerequisites / notice

The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver roos (oliver.roos@sipo.gess.ethz.ch).

Taught competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

853-0725-00L

History Part One: Europe (The Cradle of Modernity, Britain, 1789-1914)

Abstract

A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series asks whether one single model of modernization prevailed on the "Old Continent" or whether we need to differentiate regionally. A special focus lies on the Swiss experience.

Objective

At the end of this lecture course, students can: (a) highlight the most important changes in the "long nineteenth century" in Europe (b) explain their long-term effects; and (c) relate these changes to global developments today.
The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.

Power Point Slides and references will be made available in digital form during the course of the semester.

Mandatory and further reading will be listed on the course plan that is made available as from the first session.

This lecture series does not build upon specific previous knowledge by the students.

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<td>853-0061-00L</td>
<td>Introduction to Cybersecurity Politics</td>
<td>3</td>
<td>W</td>
<td>M. Dunn Cavelty, F. J. Egloff</td>
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<td>853-8002-00L</td>
<td>The Role of Technology in National and International Security Policy</td>
<td>3</td>
<td>W</td>
<td>A. Wengen, A. Dossi, M. Leese, O. Thranert</td>
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<tr>
<td>851-0650-00L</td>
<td>AliGood</td>
<td>3</td>
<td>W</td>
<td>J. D. Wegner</td>
</tr>
</tbody>
</table>

Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

A script with background information and comments on the literature will be made available at the beginning of the semester. Literature for each session will be available on Moodle.

The lecture is being supported by a website on Moodle.

The procedure for accumulating CP will be explained at the start of term.

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

We start with an overview of cybersecurity issue from 1980 to today and look at events and actors responsible for turning cybersecurity into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and technical regulatory contexts).

Of course, we will also discuss the introduction of machine learning and artificial intelligence, the implications of more and more powerful cyber weapons, and the development of hybrid warfare. Finally, we will look at the role of the state in the formulation and implementation of national and international cybersecurity policies.

This lecture series does not build upon specific previous knowledge by the students.
Objective

Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content

The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning.

Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

Prerequisites / notice

Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0742-01L  Contract Design II  W  1 credit  1U  A. Stremitzer

Abstract

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

Objective

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This seminar is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

Prerequisites / notice

To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

851-0426-00L  Paul Feyerabend’s Anarchistic Theory of Knowledge  W  3 credits  2S  M. Hagner, M. Hampe

Abstract

Paul K. Feyerabend characterized his magnum opus “Against method” as an ‘anarchistic theory of knowledge’. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Content

We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

D-PHYS

851-0101-86L  Complex Social Systems: Modeling Agents, Learning, and Games  W  3 credits  2S  N. Antulov-Fantulin, D. Carpentras, D. Helbing

Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract

This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming-language environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

Content

Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lecture notes

The lecture slides will be presented on the course web page after each lecture.
Adaptability and Flexibility

J. D. Wegner

Analytical Competencies

3 credits

The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Further literature will be recommended in the lectures.

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

851-0650-00L AI4Good

W 3 credits 2G J. D. Wegner

Abstract

The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective

Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content

The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students’ initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice

Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0197-00L Medieval and Early Modern Science and Philosophy

W 3 credits 2V to be announced

Abstract

Does not take place this semester.

The course analyses the evolution of the relation between science and philosophy during the Middle Age and the Early Modern Period.

Objective

The course aims are:
- to introduce students to the philosophical dimension of science;
- to develop a critical understanding of scientific notions;
- to acquire skills in order to read and comment on scientific texts written in the past ages.

Content

The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.

851-0742-01L Contract Design II

W 1 credit 1U A. Stremitzer

Does not take place this semester.

This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).
To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

**Abstract**
Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a hypothetical client organization planning to enter a complex transaction on how to structure the underlying contract.

**Objective**
There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer’s Teaching Assistant Diego Caldera (diegocalberto.caldaraherrera@uzh.ch).

**Prerequisites / notice**
To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

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**851-0426-00L**

**Paul Feyerabend's Anarchistic Theory of Knowledge**

**W** 3 credits 2S M. Hagner, M. Hampe

**Abstract**
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

**Objective**
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

**Content**
We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

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**851-0601-00L**

**Participatory Resilience**

**W** 3 credits 3G D. Helbing, J. Argota Sánchez-Vaquerizo, C. I. Hausladen, S. Mahajan

**Abstract**
The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

**Objective**
The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

**Content**
The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon’s central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

**Prerequisites / notice**
Please visit our website: https://participatoryresilience.ch/

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**D-USYS**

**Number**
860-0023-00L

**Title**
International Environmental Politics

**Type**
W

**ECTS**
3 credits

**Hours**
2V

**Lecturers**
T. Bernauer

**Abstract**
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

**Objective**
The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

**Content**
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

**Lecture notes**
Reading materials and slides will be available via Moodle.

**Prerequisites / notice**
Particularly suitable for students of D-ITET, D-USYS.

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

701-0703-00L Environmental Ethics

Abstract
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Content
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Lecture notes
Presentation slides of the individual theories and keywords; extended reading lists.

Literature
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O'Neill et al., Environmental Values, 2008

Generel introductions:
- Marcus Düwell et al. (Hrsg.), Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006
- Johann S. Ach et al. (Hrsg.), Grundkurs Ethik 1, Grundlagen, Paderborn (mentis) 2008

Prerequisites / notice
The procedure for accumulating CP will be explained at the start of term.

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

701-0747-00L Environmental Policy of Switzerland

Abstract
This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a public policy perspective both theoretically as well as by means of current Swiss environmental policy examples.

Objective
Beyond acquiring basic knowledge about public policy analysis, this course teaches students how to analytically address current and concrete questions of environmental policy. Through exercises the students learn about political science concepts and frameworks as well as real-life political decision-making processes. The well-grounded examination of complex political conflict situations is an important precondition for the entry into the (environmental policy) workforce or a future research career.

Content
The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

Lecture notes
The reader and additional lecture material and exercises will be posted on Moodle.

Literature
Reader and additional lecture material on moodle.

Prerequisites / notice
The detailed semester program (syllabus) is made available to the students at the beginning of the semester.

During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.

Taught competencies
Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Analytical Competencies
Social Competencies: Sensitivity to Diversity
Personal Competencies: Critical Thinking
Self-direction and Self-management

851-0650-00L AI4Good

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective.

Particularity suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective. While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Particularly suitable for students of D-ARCH, D-BAUG, D-USYS

There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Paul K. Feyerabend characterized his magnum opus "Against method" as an "anarchistic theory of knowledge". In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.
The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

Only the courses listed below will be recognized as "Science in Perspective" courses.

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

**Language Courses of the UZH and ETH Zurich**

A maximum of 3 credit points from language courses may be recognised in the category "Science in Context" throughout the entire bachelor's and master's degree program. Moreover, the following restrictions apply: In the case of the European languages English, French, Italian and Spanish, only advanced language courses from level B2 will be credited. German language courses are credited from level C2.

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
851-0816-07L | French B2-C1: Language and Literature | W | 2 credits | 1G | University lecturers
| No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich". |
| Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html |
| Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html |

**Abstract**

This course offers participants the opportunity to read short stories in order to raise their awareness of linguistic aspects and cultural issues in the Francophone world, and to improve their oral skills, mainly through oral presentations.

**Objective**

The primary objective of this course is to develop participants' written comprehension and, more specifically, to refine their perception of the implicit meanings and cultural aspects present in the literary texts proposed for reading. The course further aims to improve participants' awareness of contemporary cultural issues in the Francophone world. Another goal is to improve participants' oral skills, specifically so they can deliver structured presentations and express personal, informed, and nuanced opinions.

851-0815-04L | French B2: Brush Up Your Skills | W | 2 credits | 2G | University lecturers
| No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich". |
| Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html |
| Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html |

**Abstract**

The course is organized around the communicative tasks that participants learn to perform. These relate to the university environment and are addressed both in terms of essential language skills at B2 level and of extra-linguistic skills (cultural knowledge, gestures, etc.) required to deal with these situations.

**Objective**

The objective of this course is to familiarize participants with the performance of communicative tasks specific to the academic world and, in so doing, to consolidate their general production and comprehension skills (oral and written) at B2 level.

851-0816-15L | French B2: Debating and Presentation Skills | W | 1 credit | 1G | University lecturers
| No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich". |
| Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html |
| Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html |

**Abstract**

This course offers participants the opportunity to initiate and practice debating in French by developing and improving specific linguistic tools in order to allow them to speak fluently in controversial discussions.

**Objective**

This course allows participants to develop their speaking skills through active contributions in debates. More specifically, it aims at participants’ production of clear and reasoned statements to ensure better communication. An additional goal is to improve participants’ listening comprehension skills.

851-0816-08L | French B2-C1: Debating and Presentation Skills | W | 1 credit | 1G | University lecturers
| No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich". |
Abstract

Based on the main controversial issues of the moment, this course offers participants the opportunity to reflect on the rhetorical tools essential to the art of debate and to put these tools into practice in order to improve their ability to express themselves quickly, effectively, and fluently.

Objective

This course allows participants to develop specific skills in oral expression, as well as comprehension, in the context of controversial discussion. After observing various practices and rhetorical tools in the art of debate in an initial phase, participants put the theory into practice in order to produce clearly structured argumentation and improve their ability to interact effectively rhetorically and quickly in a controversial debate.

851-0816-05L French B2-C1: Textual Grammar

W

2 credits

1G

University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Abstract

This course offers participants the opportunity to recognize, practice, and improve some of the fundamental and relevant linguistic tools they need in order to write academic texts in French.

Objective

The main objective of this course is to improve participants' competence in written French through the mastery of grammatical rules and their practical application; this will ensure the correctness of participants' utterances at text level and help them with some difficult areas of the French language. The course focuses on a descriptive approach of linguistic tools to improve written academic French (reports, abstracts) and business writing in general (covering letters) through targeted exercises.

851-0826-06L Italian B2-C1: Outside the Classroom

W

2 credits

2G

University lecturers

Does not take place this semester.

Abstract

This course allows participants to practice Italian in a real-life situation: At the Zurich art museum (Kunsthaus), participants look at art works while listening to an Italian audio guide; they then discuss the art. The course alternates between seven museum visits and seven in-class lessons. At home, participants study their chosen art works in more depth and prepare oral and written summaries.

Objective

The course uses art as a means for participants to practice all four language skills: Reading, writing, speaking, and listening. Further activities enable participants to enhance vocabulary and grammar learning. Participants receive written feedback on their written work, and recurring errors are discussed in class.

851-0823-00L English Language and Literature (C1-C2)

W

2 credits

2G

University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Abstract

The course gives participants the opportunity to broaden and intensify their knowledge of complex morphosyntactic structures. The objective is to improve their proficiency in expressing complex content. The aim is that at the end of the course, participants understand a wide range of texts and are able to express themselves clearly and effectively in a wide variety of oral and written situations.

Objective

The course helps participants to explore various ways in which they can express complex thoughts and ideas through different types of subordinate clauses, including consecutive, concessive, and hypothetical sentences, and indirect speech. Using a range of written and oral activities, participants also practice aspects of grammar that often pose difficulties at an advanced level: verb tenses and modes, use of articles and pronouns, adjectives and past participle agreement, choice of prepositions, and word order. At the same time, the course focuses on vocabulary expansion.
The course is open to participants who have already reached C1-level English. The course enhances participants' appreciation and understanding of literature in English. Through the analysis and interpretation of literary texts, participants improve their analytical and English language skills; their grammar skills through writing; and their vocabulary through reading, discussions, and writing.

The aims of the course are to:

* Introduce participants to a variety of literary texts in English
* Help participants to develop critical, creative, and personal approaches to analyzing literary texts and by extension become more astute readers in general
* Provide participants with an opportunity to enhance and practice their argumentation skills in discussions and in writing
* Improve the ways in which participants organize their ideas and arguments in a sustained, coherent, and logical manner
* Impart a life-long interest in literature written in English

Participants should already have reached C1 level (advanced) as defined in the Common European Framework of Reference for Languages (CEFR). The course is also open to participants whose level is above C1.

The course aims to train and develop linguistic skills at mastery level, with a focus on formal and informal academic lexicon, on listening and oral communication skills, and on increasing fluency, accuracy, and complexity of spoken language. Students will work on writing well-structured descriptive texts and argumentative essays, with the aim of fulfilling the language requirements for study at an English-speaking university or following university Master's courses held in English.

Participants are able to write clear and detailed texts on scientific issues from their specific fields of study.

The most important grammar topics of this course are past tense forms, subordinate clauses, linking devices, reported speech, periphrastic verb constructions, and verbs that express change. The course also deals with topics that typically cause problems for higher level learners, including ser/estar, por/para, and indicative and subjunctive forms of verbs.

In this course, participants improve their comprehension of written and oral texts that deal with current issues, as well as of scientific texts from participants' own fields of study. They are able to analyse various points of view and can create clear and detailed oral and written texts on scientific issues from their field of study, while taking a position and expressing definite views on these issues.

This course is designed for Bachelor's and Master's students from all disciplines who wish to improve their English from C1 towards C2 level and train their language skills at mastery level. Selected academic English features are included to add value to the course to meet standard entrance requirements by leading universities and colleges worldwide.

Participants should already have reached C1 level (advanced) as defined in the Common European Framework of Reference for Languages (CEFR). The course is also open to participants whose level is above C1.

This course is designed for Bachelor's and Master's students from all disciplines who wish to improve their English from C1 towards C2 level and train their language skills at mastery level. Selected academic English features are included to add value to the course to meet standard entrance requirements by leading universities and colleges worldwide.

Participants should already have reached C1 level (advanced) as defined in the Common European Framework of Reference for Languages (CEFR). The course is also open to participants whose level is above C1.

Participants improve their understanding of grammatical usage by investigating written and spoken texts. They put newly acquired language patterns into practice when writing and speaking, and they acquire vocabulary on current contemporary issues; they also acquire specialist vocabulary from their fields of study.

Participants are able to write clear and detailed texts on scientific issues from their specific fields of study.

* Impart a life-long interest in literature written in English
* Improve participants' grammatical and lexical repertoire through reading and discussion
* Improve the ways in which participants organize their ideas and arguments in a sustained, coherent, and logical manner
* Impart a life-long interest in literature written in English
Modern Greek I leads to A1.1 level on the Common European Framework of Reference for Languages. It is the first part of a four-semester Modern Greek Language I A1.1

Participants can talk and write about themselves and everyday topics using simple sentences. They can take part in simple daily conversations, understand and write simple messages, describe an event in a time sequence, and express wishes, assumptions, and recommendations.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Language</th>
<th>Credits</th>
<th>Semester</th>
<th>University Lecturers</th>
</tr>
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<tbody>
<tr>
<td>851-0849-02L</td>
<td>Brazilian Portuguese B1</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0885-09L</td>
<td>Modern Greek Language I A1.1</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>University lecturers</td>
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<tr>
<td>851-0885-10L</td>
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<td>W</td>
<td>2</td>
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<td>University lecturers</td>
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<tr>
<td>851-0889-00L</td>
<td>Swedish I A1.2</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>
Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A1.2 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life.

Objective Participants are able to use Swedish adequately in selected areas. The focus is on speaking, reading comprehension, and listening competence. Special importance is attached to an academic environment and student life.

Abstract Swedish I leads to A1.2 level on the Common European Framework of Reference for Languages. The course is the first part of a two-semester Swedish course. The goal of the course is for participants to gain basic language skills in speaking, listening, reading, and writing.

Objective Swedish II leads to A2.1 level on the Common European Framework of Reference for Languages. The course is the second part of a two-semester Swedish course. The goal of the course is for participants to extend their skills in speaking, listening, reading, and writing. Participants expand their skills in basic grammar, extend their vocabulary and improve their pronunciation.

Abstract Russian I is the first part of a five-semester Russian course. The course leads to A1.1 level on the Common European Framework of Reference for Languages. The goal of the course is to introduce participants to the Cyrillic alphabet and to Russian phonetics; participants build up a basic vocabulary, learn the basics of Russian grammar, and are introduced to Russian culture.

Objective Russian III leads to A2.1 level on the Common European Framework of Reference for Languages. The course is the third part of a five-semester Russian course. In this course, participants extend their ability to express themselves, in particular regarding daily life (eating, shopping) and work and education (daily routines); it also extends participants’ grammar skills.

Abstract Russian V leads to A2.2 level on the Common European Framework of Reference for Languages. The course is the fourth part of a five-semester Russian course. In this course, participants extend their ability to express themselves, in particular regarding daily life (eating, shopping) and future work and education (daily routines); it also extends participants’ grammar skills.

Objective Russian V leads to A2.2 level on the Common European Framework of Reference for Languages. The course is the fourth part of a five-semester Russian course. In this course, participants extend their ability to express themselves, in particular regarding daily life (eating, shopping) and future work and education (daily routines); it also extends participants’ grammar skills.
### Objective
Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A2.2+ level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. The course deals with the following content:

- Talking about the weather; naming the seasons and months; understanding activities offered to tourists; expressing agreement, disagreement, and indifference; making appointments; talking about holiday plans and arrangements; expressing prohibitions; making comparisons; talking about learning; indicating date and year; saying what you are interested in and what you are doing; giving biographical details; saying what you would like to do; making and obtaining recommendations; passing on information.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Level</th>
<th>Credits</th>
<th>Semester</th>
<th>University Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0861-01L</td>
<td>Arabic I A1.1</td>
<td>W</td>
<td>2</td>
<td>3G</td>
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<tr>
<td>851-0863-00L</td>
<td>Arabic III A2.1</td>
<td>W</td>
<td>2</td>
<td>2G</td>
</tr>
<tr>
<td>851-0877-00L</td>
<td>Chinese I A1.1</td>
<td>W</td>
<td>3</td>
<td>4G</td>
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<tr>
<td>851-0879-00L</td>
<td>Chinese III A2.1</td>
<td>W</td>
<td>3</td>
<td>4G</td>
</tr>
</tbody>
</table>
Abstract
Chinese III leads to A2.1 level on the Common European Framework of Reference for Languages. It provides an extension of participants' skills in standard modern Chinese and in Chinese script. The goal of the course is for participants to communicate in and deal with more complex everyday situations. Special importance is attached to an academic environment and student life.

Objective
Participants are able to use the Chinese language adequately in selected areas and can conduct themselves in a culturally appropriate manner. The focus is on oral language skills at A2.1 level of the Common European Framework of Reference for Languages; reading and writing skills are fostered simultaneously. Special importance is attached to an academic environment and student life. Participants learn about 200 new characters. (After three semesters, participants know about 600 characters). Content areas that are embedded in various communicative tasks include: Directions, your living situation, public transport, visits to doctors and hospitals, hairdresser appointments.

851-0881-02L  
Japanese I (A1.1)  
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich":

Course fees:  

Registration dates:  

Abstract
Japanese I leads to A1.1 level on the Common European Framework of Reference for Languages. It is the first part of a five-semester Japanese course. The goal of the course is for participants to learn the basic vocabulary and sentence structures needed to communicate in everyday situations. This includes an introduction to Hiragana and Katakana syllabic writing and its use in word processing.

Objective
Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Special importance is attached to an academic environment and student life. In addition, the two syllabic writing systems and the use of Japanese computer word processing are learnt. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and talking about yourself (personal and professional identity, studies, interests, daily life); asking for information; and requesting services.

851-0883-00L  
Japanese III A2.1  
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich":

Course fees:  

Registration dates:  

Abstract
Japanese III leads to A1.2/A2.1 level on the Common European Framework of Reference for Languages. It is the third part of a five-semester Japanese course. The goal of the course is to give participants the opportunity to practice colloquial Japanese, read texts in Sino-Japanese mixed script, use and extend their basic vocabulary and sentence structures, and practice listening comprehension.

Objective
Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.2/A2.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Grammar skills are also reviewed and extended. Participants learn about 60 new Kanji, thus improving their reading skills. The following content from daily interactions is dealt with: Dealing with everyday interactions, talking about yourself and others (personal and professional identity, education and work, leisure time), describing personal preferences, giving advice, expressing wishes, and making assumptions.

851-0882-02L  
Japanese V A2.2 - B1.1  
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich":

Course fees:  

Registration dates:  

Abstract
Japanese V leads to A2.2/B1.1 level on the Common European Framework of Reference for Languages. It is the final part of a five-semester Japanese course. The goal of the course is to give participants the opportunity to practice colloquial Japanese, read texts in Sino-Japanese mixed script, extend their basic vocabulary and sentence structures, and practice listening comprehension.

Objective
Participants are able to communicate orally in specific situations and read everyday texts in Sino-Japanese mixed script. The focus is equally on fostering speaking, listening, writing, and reading skills at A2.2/B1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. The following content from daily interactions is dealt with: Various daily activities (logical sequences, expressing regrettable and gratifying events), distinguishing between, and using, deferential and informal language.

851-0890-00L  
Latin Reading Course: "Omnia vincit Amor": Love Stories from the Poet Ovid  

W  2 credits  2G  University lecturers
This course offers participants the opportunity to read, and reflect in class on, challenging texts on societal issues that regularly appear on
Spanish B2-C1: The Realities of the Hispanic World
Brazilian Portuguese A2-B2: Urban Popular Music

On the basis of didactically prepared texts (especially from Ovid) unfamiliar stories will be read and examined. Metrical reading
University lecturers

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>ECTS</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0900-03L</td>
<td>Advanced Norwegian Practice (University of Zürich)</td>
<td>W 3</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0856-06L</td>
<td>Spanish B2-C1: The Realities of the Hispanic World</td>
<td>W 2</td>
<td>2G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0827-01L</td>
<td>French B2.2-C1: Society and Current Issues</td>
<td>W 2</td>
<td>1G</td>
<td>University lecturers</td>
</tr>
<tr>
<td>851-0849-03L</td>
<td>Brazilian Portuguese A2-B2: Urban Popular Music</td>
<td>W 2</td>
<td>1G</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

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Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract
In this course, participants engage with various themes of urban popular music in Brazil. They gain an understanding of some aspects of culture and the history of Brazil in relation to various music genres, periods of artistic expression, main composers, and interpreters of Brazilian music.

Objective
The aim of this course is to expose the participants to the language with a musical approach using linguistic and cultural resources to develop and improve their oral and written learning and communication skills.

851-0846-02L Spanish B2-C1: Language and Cinema

Does not take place this semester.
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract
The course introduces specific thematics in Spanish-speaking regions or countries through the cinema, taking into account the geopolitical and cultural spectrum of the Spanish language.

Objective
The course aims to visual observation, development of ideas, presentation, and interaction. Some basic elements of movie-making are presented.
The participant gets familiarized with images, customs, dialogues and vocabulary, carrying out an observation, analysis, and comment of these elements.
Glossaries of different linguistic regions are created.

851-0856-04L Spanish B2-C1: Grammar and Communication

Does not take place this semester.
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract
The main subject matter of this course includes a systematic discussion of the usage of past tenses; subordinate clauses; linking expressions; reported speech; periphrastic verb constructions; and verbs of change. In addition, participants undertake individual reading of various text types, with a particular emphasis on technical subjects and/or subjects related to their fields of study

851-0816-13L French B2-C1: Language and Cinema

Does not take place this semester.
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract
This course offers participants a choice of films that reflect recent issues in order to raise their awareness of the ongoing concerns of contemporary French cinema, and also to enable them to improve their speaking skills, mainly through oral presentations.
Objective

The primary objective of this course is to develop participants' listening comprehension skills and more specifically, to improve their understanding of implicit and cultural meanings of the films on the program. It further aims to raise participants' awareness of the history, aesthetics, and contemporary issues of French cinema. The second objective of the course is to improve participants' speaking skills, especially by giving them the opportunity to produce structured presentations and to express their personal, informed, and nuanced opinions.

851-0834-17L Spanish B2: Oral Interaction

Does not take place this semester.

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

Registration dates: https://www.sprachzentrum.uzh.ch/en/Sprachkurse.html

Abstract

Participants practice a range of oral interactions, such as casual and formal conversation, interviews, debates, negotiations, and presentations. They discuss current issues and their fields of study and/or work.

Objective

The course aims to expose participants to a range of conversational situations, providing them with tools that help them to improve their ability to perform various tasks linguistically and socially.

851-0826-04L Italian B2-C1: Language and Literature

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

Registration dates: https://www.sprachzentrum.uzh.ch/en/Sprachkurse.html

Abstract

The course approaches the Italian language through short stories, relevant both for their linguistic structures and content, which is related to historical and sociological realities typical for Italy. Participants discuss current issues and their fields of study and/or work.

Objective

The course offers participants the opportunity to:
- Better understand complex literary texts
- Be able to grasp nuances of meaning expressed through certain lexical and syntactical choices more effectively
- Learn how to express themselves clearly and in a differentiated way
- Understand through short narrative texts some cultural and social realities typical of Italy

851-0826-05L Italian B2: Italian for Academic Purposes

Does not take place this semester.

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

Registration dates: https://www.sprachzentrum.uzh.ch/en/Sprachkurse.html

Abstract

In this course, participants examine and write/prepare various academic text genres, including scientific essays, abstracts, oral presentations, and handouts.

Objective

The course aims to deepen participants’ mastery of academic language. By reading scientific texts and listening to university lectures, participants analyze and study the linguistic structures of these text genres and learn specialist vocabulary from their field of study.

851-0879-01L Chinese V 2.2+

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

Registration dates: https://www.sprachzentrum.uzh.ch/en/Sprachkurse.html

Abstract

Chinese V requires level A2.2. of the Common European Framework of Reference. The goal of the course is for participants to communicate orally about selected topics from different areas.

Objective

The participants are able to talk about selected topics. The focus is on oral language skills. However, listening, reading and writing skills are also trained. Participants can work with texts or audios/videos using aids such as pop-up dictionaries and writing on the computer.

Content

- Handwriting is not required. They learn to acquire the key vocabulary and to develop idioms for each topic. The students practice, for example, how to express a fact, their own opinion, criticism, agreement, concerns, etc. and how to respond to them.

Lecture notes

This course will be supported by a module in OLAT. The participants will be asked to do some of their portfolios on OLAT.

Literature

- HSK Standard Course 4, Teil 1, HSK标准教程4 上 (含1MP3)
  ISBN: 9787561939031 und HSK标准教程4 上 练习册 (含1MP3)

Prerequisites / notice

It is mandatory that the course Chinese IV has been successfully completed. Or else, a certificate of the HSK 3 examination in the last two years is provided.
Arabic I-III (Fast Track) A1-A2.1

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract
Arabic I-III (fast track) leads as intensive course to A2.1 level on the Common European Framework of Reference for Language. The target group are people understanding or speaking an Arabic dialect who want to learn Standard Arabic, people who are able to read the Arabic script without speaking Arabic, and people having a lot of experience in learning languages who can invest plenty of time.

Objective
Participants are able to use the Arabic language adequately in selected areas and can conduct themselves in a culturally appropriate manner. To this end, the following content is dealt with: Talking about your life; daily routines; expressing wishes, commands, and eventualities, talking about language and language learning (meta-language skills), writing messages and short texts. In terms of grammar, this course attaches particular importance to the basic principles of the grammar of Standard Arabic and its verbal system. Among the cultural and meta-language skills are the creation of awareness regarding the difference between the Arabic varieties and registers.

## Science in Perspective - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>E-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible for credits and recommended</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Z</td>
</tr>
<tr>
<td>Compulsory</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Dr</td>
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<tr>
<td>Eligible for credits</td>
<td>Suitable for doctorate</td>
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## Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>lecture</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>G</td>
<td>A</td>
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<tr>
<td>lecture with exercise</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>D</td>
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<tr>
<td>exercise</td>
<td>diploma thesis</td>
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<td>R</td>
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<tr>
<td>seminar</td>
<td>revision course / private study</td>
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<tr>
<td>K</td>
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<tr>
<td>colloquium</td>
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</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.